CHAPTER

5

NEWTON'S LAWS OF MOTION

SECTION A: TOPICWISE QUESTIONS

Basics of Newton's Laws of Motion

1. Inertia is that property of a body by virtue of which the body is
(a) unable to change by itself the state of rest.
(b) unable to change by itself the state of uniform motion.
(c) unable to change by itself the direction of motion.
(d) unable to change by itself the state of rest or of uniform motion.

2. A ball is travelling with uniform translatory motion. This means that
(a) it is at rest.
(b) the path can be a straight line or circular and the ball travels with uniform speed.
(c) all parts of the ball have the same velocity (magnitude and direction) and the velocity is constant.
(d) the centre of the ball moves with constant velocity and the ball spins about its centre uniformly.

3. When a body is stationary:
(a) there is no force acting on it
(b) the forces acting on its are not in contact with it
(c) the combination of forces acting on it balance each other
(d) the body is in vacuum

4. The relation $\vec{F} = m\vec{a}$, cannot be deduced from Newton's second law, if
(a) force depends on time
(b) momentum depends on time
(c) acceleration depends on time
(d) mass depends on time

5. An astronaut accidentally gets separated out of his small spaceship accelerating in interstellar space at a constant rate of 100 m s^{-2}. What is the acceleration of the astronaut the instant after he is outside the spaceship?
(Assume that there are no nearby stars to exert gravitational force on him)
(a) zero
(b) 10 m s^{-2}
(c) 50 m s^{-2}
(d) 100 m s^{-2}

6. In which of the following cases the net force acting on the body is not zero?
(a) A drop of rain falling down with a constant speed.
(b) A cork of mass 10 g floating on the surface of water.
(c) A car moving with a constant speed of 20 km h^{-1} on a rough road.
(d) A pebble of mass 0.05 kg is thrown vertically upwards.

7. Which one of the following statements is not true about Newton's second law of motion $\vec{F} = m\vec{a}$?
(a) The second law of motion is consistent with the first law.
(b) The second law of motion is a vector law.
(c) The second law of motion is applicable to a single point particle.
(d) The second law of motion is not a local law.

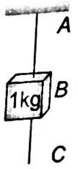
8. A boy sitting on the topmost berth in the compartment of a train which is just going to stop on a railway station, drops an apple aiming at the open hand of his brother sitting vertically below his hands at a distance of about 2 meter. The apple will fall
(a) Precisely on the hand of his brother
(b) Slightly away from the hand of his brother in the direction of motion of the train

(c) Slightly away from the hand of his brother in the direction opposite to the direction of motion of the train
(d) None of these

9. A person sitting in an open car moving at constant velocity throws a ball vertically up into air. The ball falls
(a) Outside the car
(b) In the car ahead of the person
(c) In the car to the side of the person
(d) Exactly in the hand which threw it up

10. On a stationary sail-boat, air is blown at the sails from a fan attached to the boat. The boat will
(a) Remain stationary
(b) Spin around
(c) Move in a direction opposite to that in which air is blown
(d) Move in the direction in which the air is blown

11. A mass of 1 kg is suspended by a string A. Another string C is connected to its lower end (see figure). If a sudden jerk is given to C, then
(a) The portion AB of the string will break
(b) The portion BC of the string will break
(c) None of the strings will break
(d) The mass will start rotating



12. In the previous problem, if the string C is stretched slowly, then
(a) The portion AB of the string will break
(b) The portion BC of the string will break
(c) None of the strings will break
(d) None of the above

13. Which of the following conclusions is correct regarding a stationary body?
(a) No force is acting on the body.
(b) Vector sum of forces acting on the body is zero.
(c) The body is in vacuum.
(d) The forces acting on the body, do not constitute a couple.

14. A locomotive (engine) pulls a series of wagons. Which is the correct analysis of the situation?
(a) The train moves forward because the locomotive pulls forward slightly harder on the wagons than the wagons pull backward on the locomotive.
(b) Because action always equals reaction, the locomotive cannot pull the wagons. The wagons pull backward just as hard as the locomotive pulls forward, there is no motion.
(c) The locomotive's force on the wagons is as strong as the force of the wagons on the locomotive, but the frictional force on the locomotive is forward and large while the backward frictional force on the wagons is small.
(d) The locomotive can pull the wagons forward only if it weighs more than the wagons.

15. When a speeding bus stops suddenly, passengers are thrown forward from their seats because
(a) the back of seat suddenly pushes the passengers forward.
(b) inertia of rest stops the bus and takes the body forward.
(c) upper part of the body continues to be in the state of motion whereas the lower part of the body in contact with seat remains at rest.
(d) upper part of the body come to rest whereas the lower part of the body in contact with seat begins to move.

16. We can derive Newton's
(a) second and third laws from the first law.
(b) first and second laws from the third law.
(c) third and first laws from the second law.
(d) all the three laws are independent of each other.

17. Which of the following statements is not true regarding the Newton's third law of motion?
(a) To every action there is always an equal and opposite reaction.
(b) Action and reaction act on the same body.
(c) There is no cause-effect relation between action and reaction.
(d) Action and reaction forces are simultaneous forces.

18. A constant retarding force of 50 N is applied to a body of mass 10 kg moving initially with a speed of 10 ms^{-1}. The body comes to rest after
(a) 2 s
(b) 4 s
(c) 6 s
(d) 8 s

19. A body A of mass m_1 exerts a force on another body B of mass m_2. If the acceleration of B be a_2, then the acceleration (in magnitude) of A is
(a) $\frac{m_2}{m_1}a_2$
(b) $m_1 m_2 a_2$
(c) $\frac{m_1}{m_2}a_2$
(d) $(m_1 + m_2)a_2$

20. When forces F_1, F_2, F_3 are acting on a particle of mass m such that F_2 and F_3 are mutually perpendicular, then the particle remains stationary. If the force F_1 is now removed then the acceleration of the particle is
(a) F_1/m
(b) F_2F_3/mF_1
(c) $(F_2 - F_3)/m$
(d) F_2/m

21. A body under the action of a force $\vec{F} = 6\hat{i} - 8\hat{j}N$ acquires an acceleration of 5 m s^{-2}. The mass of the body is
(a) 2 kg
(b) 5 kg
(c) 4 kg
(d) 6 kg

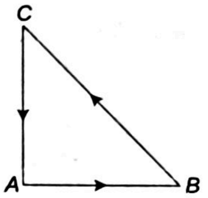
22. A constant force acting on a body of mass of 5 kg change its speed from 5 m s^{-1} to 10 m s^{-1} in 10 s without changing the direction of motion. The force acting on the body is
(a) 1.5 N
(b) 2 N
(c) 2.5 N
(d) 5 N

23. A body of mass 0.4 kg starting at origin at $t = 0$ with a speed of 10 m s^{-1} in the positive x-axis direction is subjected to a constant $F = 8$ N towards negative x-axis. The position of the body after 25 s is

(a) –6000 m (b) –8000 m

(c) +4000 m (d) +7000 m

24. Three forces starts acting simultaneously on a particle moving with velocity $\vec{v}$. These forces are represented in magnitude and direction by the three sides of a triangle ABC (as shown). The particle will now move with velocity



(a) $\vec{v}$ remaining unchanged

(b) Less than $\vec{v}$

(c) Greater than $\vec{v}$

(d) $\vec{v}$ in the direction of the largest force BC

25. Five forces $\vec{F_1}, \vec{F_2}, \vec{F_3}, \vec{F_4}$ and $\vec{F_5}$ are acting on a particle of mass 2.0 kg so that it is moving with 4 m/s^2 in east direction. If $\vec{F_1}$ force is removed, then the acceleration becomes 7 m/s^2 in north, then the acceleration of the block if only $\vec{F_1}$ is acting will be:

(a) 16 m/s^2 (b) $\sqrt{65}$ ms^2

(c) $\sqrt{260}$ ms^2 (d) $\sqrt{33}$ ms^2

26. Ten one-rupee coins are put on top of each other on a table. Each coin has a mass m. The reaction of the 6th coin (counted from the bottom) on the 7th coin is

(a) 4 mg (b) 6 mg

(c) 7 mg (d) 3 mg

27. A cork of mass 10 g is floating on water. The net force acting on the cork is

(a) 10 N (b) 10^{-3} N

(c) 10^{-2} N (d) zero

28. A bullet of mass 40 g moving with a speed of 90 m s^{-1} enters a heavy wooden block and is stopped after a distance of 60 cm. The average resistive force exerted by the block on the bullet is

(a) 180 N (b) 220 N

(c) 270 N (d) 320 N

29. Five persons A, B, C, D and E are pulling a cart of mass 100 kg on a smooth surface and cart is moving with acceleration 3 m/s^2 in east direction. When person A stops pulling, it moves with acceleration 1 m/s^2 in the west direction. When person B stops pulling, it moves with acceleration 24 m/s^2 in the north direction. The magnitude of acceleration of the cart when only A and B pull the cart keeping their directions same as the old directions, is:

(a) 26 m/s^2 (b) $3\sqrt{71}$ m/s^2

(c) 25 m/s^2 (d) 30 m/s^2

30. A machine gun is mounted on a 2000 kg car on a horizontal frictionless surface. At some instant the gun fires bullets of mass 10 gm with a velocity of 500 m/sec with respect to the car. The number of bullets fired per second is ten. The average thrust on the system is

(a) 550 N (b) 50 N

(c) 250 N (d) 250 dyne

31. A machine gun fires a bullet of mass 40 g with a velocity1200 ms^{-1}. The man holding it can exert a maximum force of 144 N on the gun. How many bullets can he fire per second at the most?

(a) One (b) Four

(c) Two (d) Three

32. If a bullet of mass 5 gm moving with velocity 100 m /sec, penetrates the wooden block upto 6 cm. Then the average force imposed by the bullet on the block is

(a) 8300 N (b) 417 N

(c) 830 N (d) Zero

33. A 5000 kg rocket is set for vertical firing. The exhaust speed is 800 ms^{-1}. To give an initial upward acceleration of 20 ms^{-2}, the amount of gas ejected per second to supply the needed thrust will be (g = 10 ms^{-2})

(a) 127.5 kg s^{-1} (b) 187.5 kg s^{-1}

(c) 185.5 kg s^{-1} (d) 137.5 kg s^{-1}

34. A cricket ball of mass 250 g collides with a bat with velocity 10 m/s and returns with the same velocity within 0.01 second. The force acted on bat is

(a) 25 N (b) 50 N

(c) 250 N (d) 500 N

35. N bullets each of mass m kg are fired with a velocity v ms^{-1} at the rate of n bullets per second upon a wall. The reaction offered by the wall to the bullets is given by

(a) nmv (b) $\frac{Nmv}{n}$

(c) $n\frac{Nm}{v}$ (d) $n\frac{Nv}{m}$

36. A ball of mass 400 gm is dropped from a height of 5 m. A boy on the ground hits the ball vertically upwards with a bat with an average force of 100 N so that it attains a vertical height of 20 m. The time for which the ball remains in contact with the bat is [g =10 m/s^2]

(a) 0.12 s (b) 0.08 s

(c) 0.04 s (d) 12 s

37. A gardener waters the plants by a pipe of diameter 1 mm. The water comes out at the rate or 10 cm^3/sec. The reactionary force exerted on the hand of the gardener is

(a) Zero (b) 1.27×10^{-2} N

(c) 1.27×10^{-4} N (d) 0.127 N

38. A 100 g iron ball having velocity 10 m/s collides with a wall at an angle 30° and rebounds with the same angle. If the period of contact between the ball and wall is 0.1 second, then the force experienced by the wall is

(a) 10 N (b) 100 N

(c) 1.0 N (d) 0.1 N

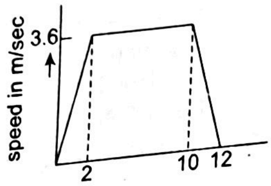
39. At a certain instant of time the mass of a rocket going up vertically is 100 kg. If it is ejecting 5 kg of gas per second at a speed of 400 m/s, the acceleration of the rocket would be (taking $g = 10\ m/s^2$)

(a) $20\ m/s^2$ (b) $10\ m/s^2$
(c) $2\ m/s^2$ (d) $1\ m/s^2$

40. A block of metal weighing 2 kg is resting on a frictionless plane. It is struck by a jet releasing water at a rate of 1 kg/s and a speed of 5 m/s. The initial acceleration of the block will be:

(a) $2.5\ m/s^2$ (b) $5\ m/s^2$
(c) $10\ m/s^2$ (d) $20\ m/s^2$

41. A lift is going up. The total mass of the lift and the passenger is 1500 kg. The variation in the speed of the lift is as given in the graph. The tension in the rope pulling the lift at $t = 11$th sec will be



(a) 17400 N (b) 14700 N
(c) 12000 N (d) Zero

42. A constant force starts acting on a body of mass m at rest. The velocity v acquired in traveling a specific distance depends on m as

(a) $v \propto \frac{1}{m}$ (b) $v \propto \frac{1}{\sqrt{m}}$
(c) $v \propto m$ (d) $v \propto \sqrt{m}$

43. Match Column I with Column II and mark the correct choice from the given codes.

	Column–I		Column–II
(A)	Definition of force	(p)	Newton's third law
(B)	Measure of force	(q)	Impulse
(C)	Effect of force	(r)	Newton's second law
(D)	Recoiling of gun	(s)	Newton's first law

Codes

(a) A–q, B – p, C – r, D – s
(b) A–p, B – q, C – r, D – s
(c) A–s, B – r, C – q, D – p
(d) A–s, B – q, C – r, D – p

Linear Momentum and Impulse

44. Which one of the following statements is not true?

(a) The same force for the same time causes the same change in momentum for different bodies.
(b) The rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction in which the force acts.
(c) A greater opposing force is needed to stop a heavy body than a light body in the same time, if they are moving with the same speed.
(d) The greater the change in the momentum in a given time, the lesser is the force that needs to be applied.

45. A particle at rest suddenly disintegrates into two particles of equal masses which start moving. The two fragments will:

(a) move in the same direction with equal speeds
(b) move in any direction with any speed
(c) move in opposite directions with equal speeds
(d) move in opposite directions with unequal speeds

46. A nuclide at rest emits an α-particle. In this process:

(a) α-particle moves with large velocity and the nucleus remains at rest
(b) both α-particle and nucleus move with equal speed in opposite directions
(c) both move in opposite directions but nucleus with greater speed
(d) both move in opposite directions but α-particle with greater speed.

47. A vessel at rest explodes breaking it into three pieces. Two pieces having equal mass fly off perpendicular to one another with the same speed of 30 m/s. The third piece has three times the mass of each other piece. What is the direction (w.r.t. the pieces having equal masses) and magnitude of its velocity immediately after the explosion?

(a) $10\sqrt{2}, 135°$ (b) $10\sqrt{2}, 90°$
(c) $10\sqrt{2}, 60°$ (d) $10\sqrt{2}, 30°$

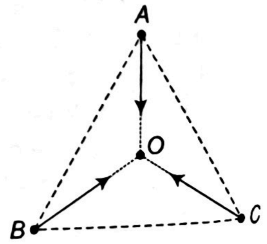
48. A radioactive nucleus initially at rest decays by emitting an electron and neutron at right angles to one another. The momentum of the electron is 3.2×10^{-23} kgm/s and the momentum of neutron is 6.4×10^{-23} kgm/sec. The direction of the recoiling nucleus with that of the electron motion is:

(a) $\pi - \tan^{-1}(2)$ (b) $\tan^{-1}(2)$
(c) $\tan^{-1}(0.5)$ (d) $\frac{\pi}{2} + \tan^{-1}(2)$

49. A shell is fired from a cannon with velocity v m/s at an angle θ with the horizontal direction. At the highest point in its path it explodes into two pieces of equal mass. One of the pieces retraces its path to the cannon and the speed in m/s of the other piece immediately after the explosion is:

(a) $3v \cos\theta$ (b) $2v \cos\theta$
(c) $\frac{3v}{2}\cos\theta$ (d) $\frac{\sqrt{3}v\cos\theta}{2}$

50. Three particles A, B and C of equal masses move with equal speeds v along the medians of an equilateral triangle. They collide at the centroid O of the triangle. After collision A comes to rest while B retraces its path with speed v. The velocity of C is then



(a) v, direction $\overrightarrow{OA}$ (b) $2v$, direction $\overrightarrow{OA}$
(c) $2v$, direction $\overrightarrow{OB}$ (d) v, direction $\overrightarrow{BO}$

51. A shell of mass 200 g is fired by a gun of mass 100 kg. If the muzzle speed of the shell is 80 m s^{-1}, then the recoil speed of the gun is
(a) 16 cm s^{-1}
(b) 8 cm s^{-1}
(c) 8 m s^{-1}
(d) 16 m s^{-1}

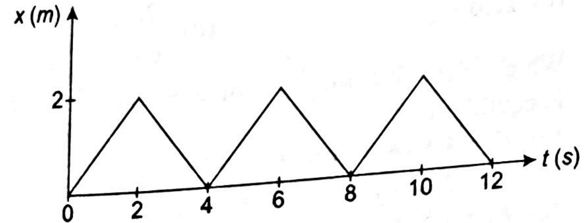
52. A 100 kg gun fires a ball of 1 kg horizontally from a cliff of height 500 m. It falls on the ground at a distance of 400 m from the bottom of the cliff. The recoil velocity of the gun is (Take g: 10 m s^{-2})
(a) 0.2 m s^{-1}
(b) 0.4 m s^{-1}
(c) 0.6 m s^{-1}
(d) 0.8 m s^{-1}

53. A body of mass M at rest explodes into three pieces, two of which of mass $M/4$ each are thrown off in perpendicular directions with velocities of 3 m/s and 4 m/s respectively. The third piece will be thrown off with a velocity of
(a) 1.5 m/s
(b) 2.0 m/s
(c) 2.5 m/s
(d) 3.0 m/s

54. A bullet is fired from a gun. The force on the bullet is given by $F = 600 - 2 \times 10^5\ t$, where F is in newtons and t in seconds. The force on the bullet becomes zero as soon as it leaves the barrel. What is the average impulse imparted to the bullet?
(a) 9 Ns
(b) Zero
(c) 0.9 Ns
(d) 1.8 Ns

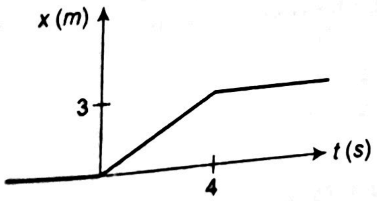
55. A particle moves in the xy-plane under the action of a force F such that the components of its linear momentum p at any time t are $p_x = 2\cos t$, $p_y = 2\sin t$. The angle between F and p at time t is
(a) 90°
(b) 0°
(c) 180°
(d) 30°

56. Figure shows the position–time (x-t) graph of one dimensional motion of a body of mass 500 g. What is the time interval between two consecutive impulses received by the body?



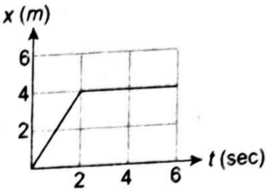
(a) 2 s
(b) 4 s
(c) 6 s
(d) 8 s

57. Figure shows the position–time graph of a particle of mass 4 kg. Let the force on the particle for $t < 0$, $0 < t < 4$ s, $t > 4$ s be F_1, F_2 and F_3 respectively. Then



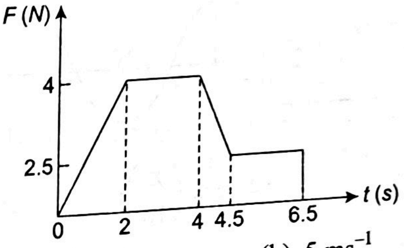
(a) $F_1 = F_2 = F_3 = 0$
(b) $F_1 > F_2 = F_3$
(c) $F_1 > F_2 > F_3$
(d) $F_1 < F_2 < F_3$

58. In the figure given below, the position–time graph of a particle of mass 0.1 kg is shown. The impulse at $t = 2$ sec is



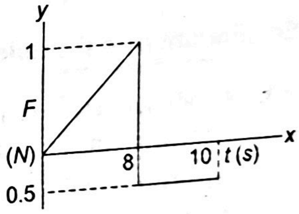
(a) 0.2 kg m sec^{-1}
(b) –0.2 kg m sec^{-1}
(c) 0.1 kg m sec^{-1}
(d) –0.4 kg m sec^{-1}

59. A body of 2 kg has an initial speed 5 ms^{-1}. A force acts on it for some time in the direction of motion. The force time graph is shown in figure. The final speed of the body is



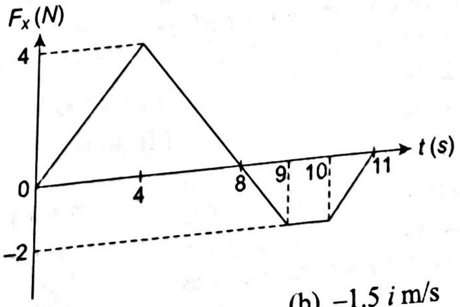
(a) 9.25 ms^{-1}
(b) 5 ms^{-1}
(c) 14.25 ms^{-1}
(d) 4.25 ms^{-1}

60. A force–time graph for the motion of a body is shown in the figure. The change in the momentum of the body between zero and 10 sec is



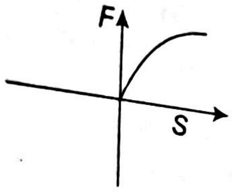
(a) zero
(b) 4 kg m/s
(c) 5 kg m/s
(d) 3 kg m/s

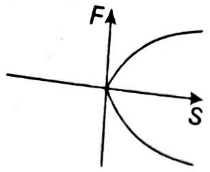
61. A 2 kg toy car can move along an x axis. Graph shows force F_x, acting on the car which begins at rest at time $t = 0$. The velocity of the particle at $t = 10$ s is:

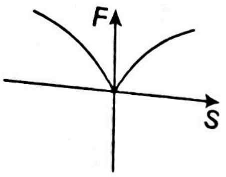


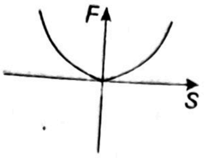
(a) $-i$ m/s
(b) $-1.5\ i$ m/s
(c) $6.5\ i$ m/s
(d) $13\ i$ m/s

62. A particle of mass 'm' and initially at rest is acted by a force $F = a\ t$. Newtons best representation of force–displacement graph is:

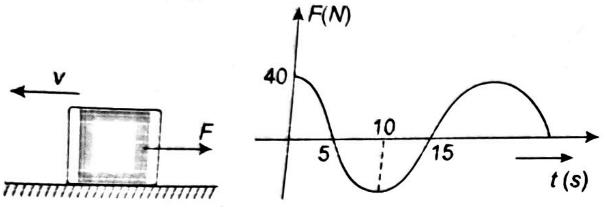
(a)


(b)


(c)


(d)


63. A 15 kg block is initially moving along a smooth horizontal surface with a speed of $v = 4$ m/s to the left. It is acted by a force F, which varies in the manner shown. Determine the velocity of the block at $t = 15$ seconds.



Given that, $F = 40\cos\left(\frac{\pi}{10}\right)t$.

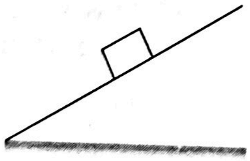
(a) 12.5 m/s
(b) 8.5 m/s
(c) 20 m/s
(d) 9.5 m/s

Equilibrium of a Particle

64. A body subjected to three concurrent forces is found to be in equilibrium. The resultant of any two forces

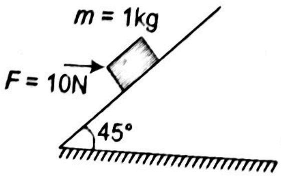
(a) is equal to third force.
(b) is opposite to third force
(c) is collinear with the third force
(d) all of these

65. A block of mass 3 kg is at rest on a rough inclined plane as shown in the figure. The magnitude of net force exerted by the surface on the block will be



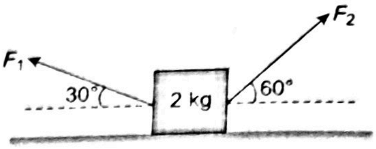
(a) 26 N
(b) 19.5 N
(c) 10 N
(d) 30 N

66. A body of mass 1 kg lies on smooth inclined plane. The block of mass m is given force $F = 10$ N horizontally as shown. The magnitude of net normal reaction on the block is:



(a) $10\sqrt{2}$ N
(b) $\frac{10}{\sqrt{2}}$ N
(c) 10 N
(d) none of these

67. A body of mass 2.0 kg is placed on a smooth horizontal surface. Two forces $F_1 = 20$ N and $F_2 =$ N are acting on the body in directions making angles of 30° and 60° to the surface. The reaction of the surface on the body will be

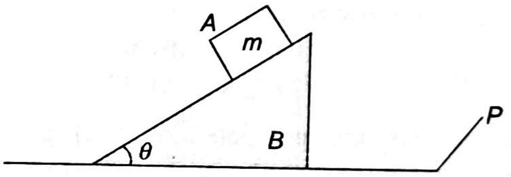


(a) 20 N
(b) 25 N
(c) 5 N
(d) zero

68. Three concurrent co-planar forces 1 N, 2 N and 3 N acting along different directions on a body

(a) can keep the body in equilibrium if 2 N and 3 N act at right angle.
(b) can keep the body in equilibrium if 1 N and 2 N act at right angle.
(c) cannot keep the body in equilibrium.
(d) can keep the body in equilibrium if 1 N and 3 N act at an acute angle.

69. In the figure shown 'P' is a plate on which a wedge B is placed and on B a block A of mass m is placed. The plate is suddenly removed and system of B and A is allowed to fall under gravity. Neglecting any force due to air on A and B, the normal force on A due to B is

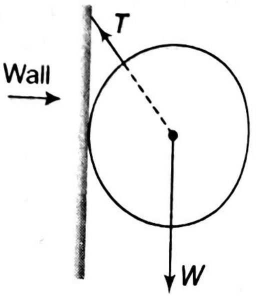


(a) $\frac{mg}{\cos\theta}$
(b) $mg\cos\theta$
(c) zero
(d) $\frac{2mg}{\cos\theta}$

70. Which of the following sets of concurrent forces may be in equilibrium?

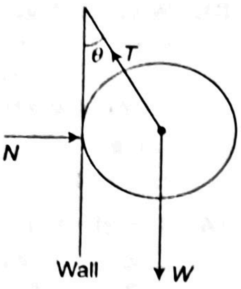
(a) $F_1 = 3$ N, $F_2 = 5$ N, $F_3 = 9$ N
(b) $F_1 = 3$ N, $F_2 = 5$ N, $F_3 = 1$ N
(c) $F_1 = 3$ N, $F_2 = 5$ N, $F_3 = 15$ N
(d) $F_1 = 3$ N, $F_2 = 5$ N, $F_3 = 6$ N

71. A uniform sphere of weight W and radius 3 m is being held by a string of length 2 m. attached to a frictionless wall as shown in the figure. The tension in the string will be:



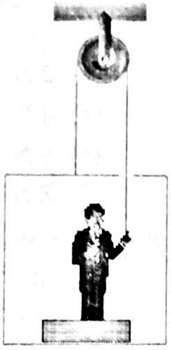
(a) 5 W/4
(b) 15 W/4
(c) 15 W/16
(d) none of these

72. A metal sphere is hung by a string fixed to a wall. The forces acting on the sphere are shown in figure. Which of the following statements is NOT correct?



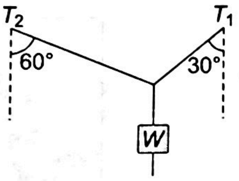
(a) $\vec{N} + \vec{T} + \vec{W} = 0$
(b) $T^2 = N^2 + W^2$
(c) $T = N + W$
(d) $N = W \tan \theta$

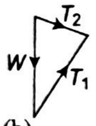
73. Figure shows a man of mass 50 kg standing on a light weighing machine kept in a box of mass 30 kg. The box is hanging from a pulley fixed to the ceiling through a light rope, the other end of which is held by the man himself. If the man manages to keep the box at rest, the weight shown by the machine is.

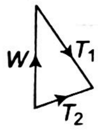


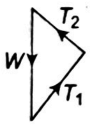
(a) 10 N
(b) 100 N
(c) 800 N
(d) 200 N

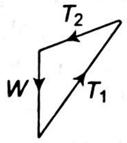
74. A weight W is supported by two strings inclined at 60° and 30° to the vertical. The tensions in the strings are T_1 and T_2 as shown. If these tensions are to be determined in terms of W using a triangle of forces, which of these triangles should you draw? (block is in equilibrium)



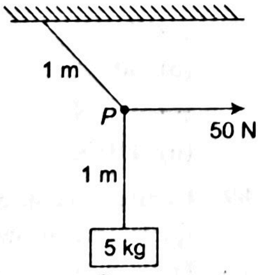
(a)


(b)


(c)


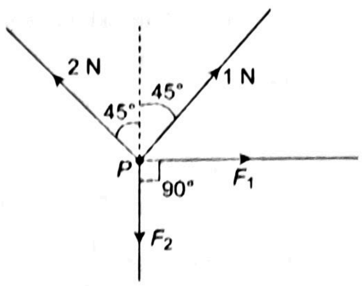
(d)


75. A block of mass 5 kg is suspended by a massless rope of length 2 m from the ceiling. A force of 50 N is applied in the horizontal direction at the midpoint P of the rope, as shown in the figure. The angle made by the rope with the vertical in equilibrium is (Take $g = 10$ m s^{-2}) m



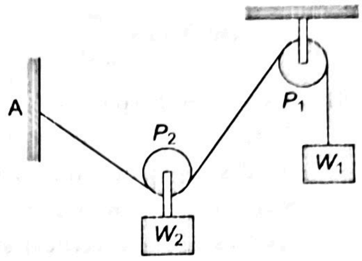
(a) 30°
(b) 40°
(c) 60°
(d) 45°

76. There are four forces acting at a point P produced by strings as shown in figure, which is at rest. The forces F_1 and F_2 are



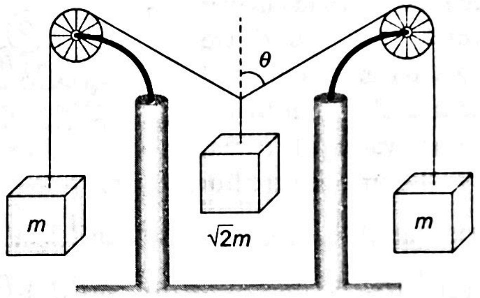
(a) $\frac{1}{\sqrt{2}}$ N, $\frac{3}{\sqrt{2}}$ N
(b) $\frac{3}{\sqrt{2}}$ N, $\frac{1}{\sqrt{2}}$ N
(c) $\frac{1}{\sqrt{2}}$ N, $\frac{1}{\sqrt{2}}$ N
(d) $\frac{3}{\sqrt{2}}$ N, $\frac{3}{\sqrt{2}}$ N

77. In the following figure, the pulley P_1 is fixed and the pulley P_2 is movable. If $W_1 = W_2 = 100$ N, what is the angle AP_2P_1? The pulleys are frictionless.



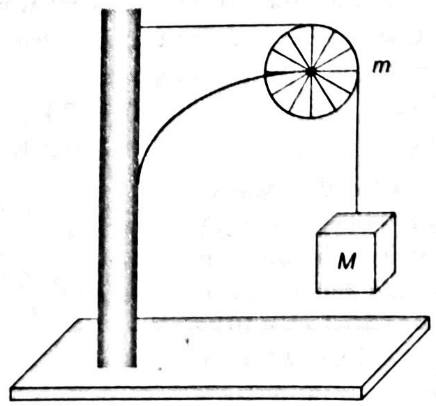
(a) 30°
(b) 60°
(c) 90°
(d) 120°

78. The pulleys and strings shown in the figure are smooth and of negligible mass. For the system to remain in equilibrium, the angle θ should be



(a) 0°
(b) 30°
(c) 45°
(d) 60°

79. A string of negligible mass going over a clamped pulley of mass m supports a block of mass M as shown in the figure. The force on the pulley by the clamp is given by



(a) $\sqrt{2}Mg$
(b) $\sqrt{2}mg$
(c) $\sqrt{(M+m)^2 + m^2}\,g$
(d) $\sqrt{(M+m)^2 + M^2}\,g$

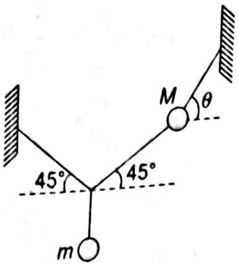
80. Two masses m and M are attached with strings as shown. For the system to be in equilibrium we have

(a) $\tan\theta = 1 + \frac{2M}{m}$

(b) $\tan\theta = 1 + \frac{2m}{M}$

(c) $\tan\theta = 1 + \frac{M}{2m}$

(d) $\tan\theta = 1 + \frac{m}{2M}$



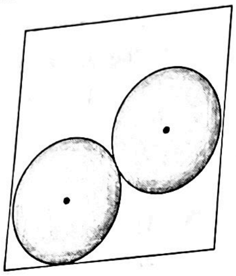
81. Two smooth spheres each of radius 5 cm and weight W rest one on the other inside a fixed smooth cylinder of radius 8 cm. The reactions between the spheres and the vertical side of the cylinder are:

(a) $W/4$ and $3W/4$

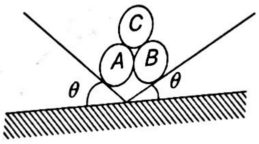
(b) $W/4$ and $W/4$

(c) $3W/4$ and $3W/4$

(d) W and W



82. Three identical rigid circular cylinders A, B and C are arranged on smooth inclined surfaces as shown in figure. The least value of θ that prevent the arrangement from collapse is



(a) $\tan^{-1}(1/2)$

(b) $\tan^{-1}(1/2\sqrt{3})$

(c) $\tan^{-1}(1/3\sqrt{3})$

(d) $\tan^{-1}(1/4\sqrt{3})$

Applications of Newton's Laws of Motion

83. Two persons are holding a rope of negligible weight tightly at its ends so that it is horizontal. A 15 kg weight is attached to the rope at the mid point which how no longer remains horizontal. The minimum tension required to completely straighten the rope is:

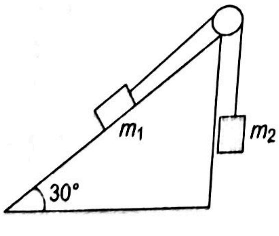
(a) 15 kg

(b) 15/2 kg

(c) 5 kg

(d) Infinitely large

84. M is a fixed wedge. Masses m_1 and m_2 are connected by a light string. The wedge is smooth and the pulley is smooth and fixed. $m_1 = 10$ kg and $m_2 = 7.5$ kg. When m_2 is just released, the distance it will travel in 2 seconds is



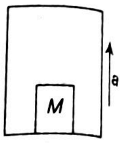
(a) 2.8 m

(b) 7.5 m

(c) 4.0 m

(d) 6.0 m

85. With what acceleration 'a' should the box of figure moving up so that the block of mass M exerts a force 7 Mg/4 on the floor of the box?



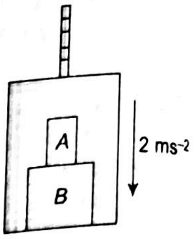
(a) $g/4$

(b) $g/2$

(c) $3g/4$

(d) $4g$

86. The elevator shown in figure is descending with an acceleration of 2 ms^{-2}. The mass of the block $A = 0.5$ kg. The force exerted by the block A on the block B is: Take $g = 10$ m/s^2.



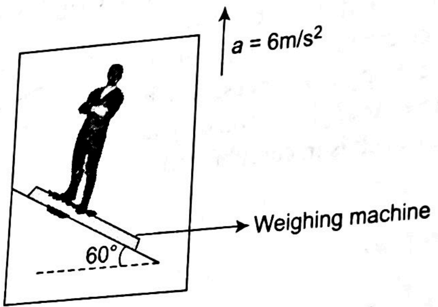
(a) 2 N

(b) 4 N

(c) 6 N

(d) 8 N

87. An elevator is accelerating upwards with an acceleration of 6 m/s^2. Inside it a person of mass 50 kg is standing on a weighing machine which is kept on an inclined plane having angle of inclination 60°. The reading of the weighing machine is:



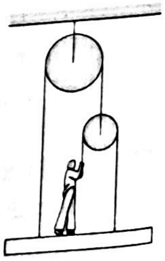
(a) 40 kg

(b) 160 kg

(c) 80 kg

(d) 50 kg

88. In the given diagram, with what force must the man pull the rope to hold the plank in position? Mass of the man is 80 kg. Neglect the weights of plank, rope and pulley. Take $g = 10$ ms^{-2}.



(a) 200 N

(b) 300 N

(c) 600 N

(d) 150 N

89. Consider the three cases given in figures shown. Assume the friction to be absent everywhere and the pulleys to be light; the string connecting the blocks to other block or fixed vertical wall to be light and inextensible . Let T_A, T_B and T_C be the tension in the strings in figure A, figure B and figure C respectively. Then pick the correct comparison between the given tensions (for the instant shown) from options below.

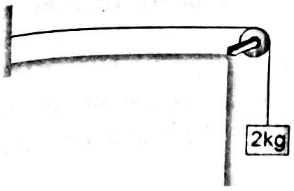


Fig. (A)

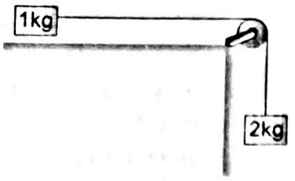


Fig. (B)

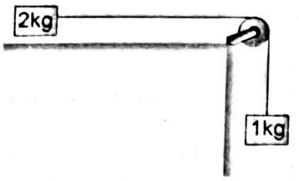
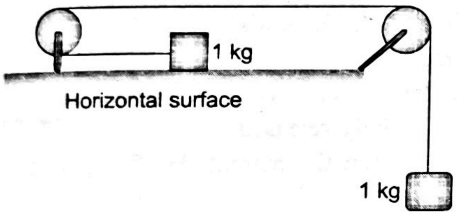


Fig. (C)

(a) $T_A = T_B = T_C$ (b) $T_B = T_C < T_A$

(c) $T_A < T_B < T_C$ (d) $T_B < T_C < T_A$

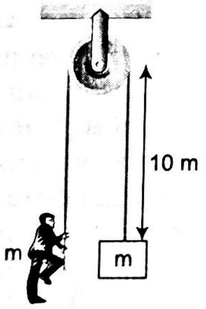
90. Consider the system as shown in the figure. The pulley and the string are light and all the surfaces are frictionless. The tension in the string is ($g = 10\ \text{m/s}^2$)



(a) 0 N (b) 1 N

(c) 2 N (d) 5 N

91. A boy and a block, both of same mass, are suspended at the same horizontal level, from each end of a light string that moves over a frictionless pulley as shown. The boy starts moving upwards with an acceleration 2.5 m/s^2 relative to the rope. If the block is to travel a total distance 10 m before reaching at the pulley, the time taken by the block in doing so is equal to:



(a) $\sqrt{8}$ s (b) 4 s

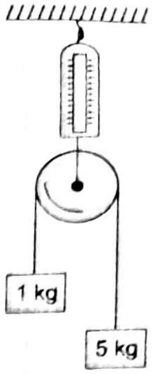
(c) $\dfrac{10}{\sqrt{2}}$ s (d) 8 s

92. In order to raise a mass of 100 kg a man of mass 60 kg fastens a rope to it and passes the rope over a smooth pulley. He climbs the rope with acceleration 5 g/4 relative to the rope. The tension in the rope is: Take $g = 10\ \text{m/s}^2$

(a) 1432 N (b) 928 N

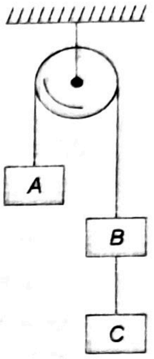
(c) 1219 N (d) 642 N

93. Two masses of 1 kg and 5 kg are attached to the ends of a massless string passing over a pulley of negligible weight. The pulley itself is attached to a light spring balance as shown in figure. The masses start moving during this interval; the reading of spring balance will be:



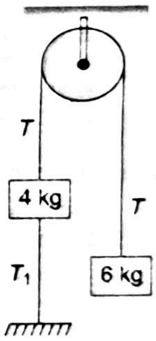
(a) more than 6 kg
(b) less than 6 kg
(c) equal to 6 kg
(d) none of the above

94. Three equal weights A, B, C of mass 2 kg each are hanging on a string passing over a fixed frictionless pulley as shown in the figure. The tension in the string connecting weights B and C is:



(a) zero
(b) 13 N
(c) 3.3 N
(d) 19.6 N

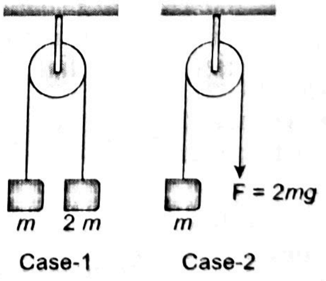
95. Two bodies of mass 4 kg and 6 kg are attached to the ends of a string passing over a pulley. The 4 kg mass is attached to the table top by another string. The tension in this string T_1 is equal to: Take $g = 10\ \text{m/s}^2$



(a) 20 N (b) 25 N

(c) 10.6 N (d) 10 N

96. Figure shows two pulley arrangements for lifting a mass m. In case-1, the mass is lifted by attaching a mass $2m$ while in case-2 the mass is lifted by pulling the other end with a downward force $F = 2\,mg$. If a_a and a_b are the accelerations of the two masses then (Assume string is massless and pulley is ideal)

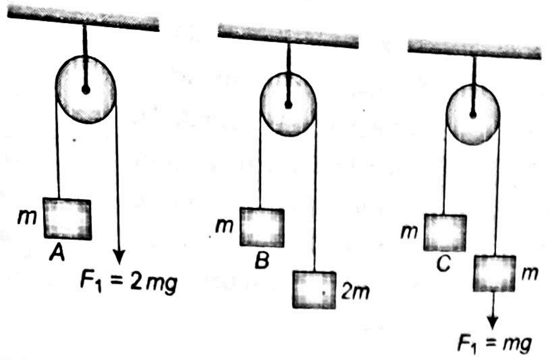


Case-1 Case-2

(a) $a_a = a_b$ (b) $a_a = a_b/2$

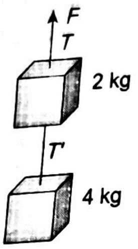
(c) $a_a = a_b/3$ (d) $a_a = 2a_b$

97. In fig., the blocks A, B and C of mass m each have accelerations a_1, a_2 and a_3 respectively. F_1 and F_2 are external forces of magnitudes $2mg$ and mg respectively. Then



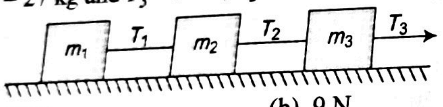
(a) $a_1 = a_2 = a_3$
(b) $a_1 > a_3 > a_2$
(c) $a_1 = a_2, a_2 > a_3$
(d) $a_1 > a_2, a_2 = a_3$

98. Two blocks are connected by a string as shown in the diagram. The upper block is hung by another string. A force F applied on the upper string produces an acceleration of 2 m/s^2 in the upward direction in both the blocks. If T and T' be the tensions in the two parts of the string, then



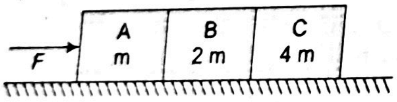
(a) $T = 70.8$ N and $T' = 47.2$ N
(b) $T = 58.8$ N and $T' = 47.2$ N
(c) $T = 70.8$ N and $T' = 58.8$ N
(d) $T = 70.8$ N and $T' = 0$

99. Three blocks are connected as shown in figure on a horizontal frictionless table. If $m_1 = 1$ kg, $m_2 = 8$ kg, $m_3 = 27$ kg and $T_3 = 36$ N, T_2 will be



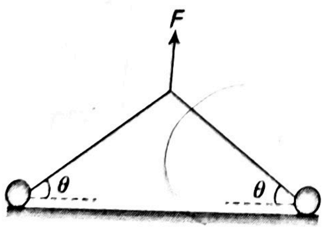
(a) 18 N
(b) 9 N
(c) 3.375 N
(d) 1.75 N

100. A force F is applied on block A as shown in figure. The contact force between the blocks A and B and between the blocks B and C respectively are (Assume frictionless surface)



(a) $\frac{F}{7}, \frac{2F}{7}$
(b) $\frac{6F}{7}, \frac{4F}{7}$
(c) $F, \frac{F}{2}$
(d) $\frac{4F}{7}, \frac{6F}{7}$

101. Two small spheres each of mass m connected by a string of length $2l$ are kept on a smooth horizontal surface. A vertical force F is applied at the middle of the string. What is maximum value of F for which the spheres do not lose contact with the surface?



(a) 2 mg
(b) mg
(c) $\frac{3\,mg}{2}$
(d) 4 mg

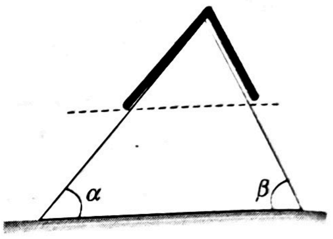
102. A perfectly straight portion of a uniform rope has mass M and length L. At end A of the segment, the tension in the rope is T_A and at end B it is T_B ($T_B > T_A$). Neglect effect of gravity and no contact force acts on the rope in between points A and B. The tension in the rope at a distance $L/5$ from end A is

(a) $T_B - T_A$
(b) $(T_A + T_B)/5$
(c) $(4T_A + T_B)/5$
(d) $(T_A - T_B)/5$

103. A block of mass M is pulled along a horizontal frictionless surface by a rope of mass m. Force P is applied at one end of rope. The force which the rope exerts on the block is:

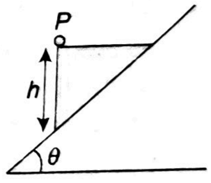
(a) $\frac{P}{(M-m)}$
(b) $\frac{P}{M(m+M)}$
(c) $\frac{PM}{(m+M)}$
(d) $\frac{PM}{(M-m)}$

104. A uniform rope of length L and mass M is placed on a smooth fixed wedge as shown. Both ends of rope are at same horizontal level. The rope is initially released from rest, then the magnitude of initial acceleration of rope is



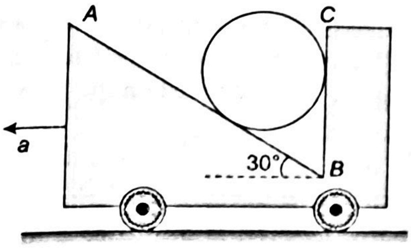
(a) Zero
(b) $M(\cos\alpha - \cos\beta)g$
(c) $M(\tan\alpha - \tan\beta)g$
(d) None of these

105. A wedge of height 'h' is released from rest with a light particle P placed on it as shown. The wedge slides down an incline which makes an angle θ with the horizontal. All the surfaces are smooth, P will reach the surface of the incline in time:



(a) $\sqrt{\frac{2h}{g\sin^2\theta}}$
(b) $\sqrt{\frac{2h}{g\sin\theta\cos\theta}}$
(c) $\sqrt{\frac{2h}{g\tan\theta}}$
(d) $\sqrt{\frac{2h}{g\cos^2\theta}}$

106. A cylinder rests in a supporting carriage as shown. The side AB of carriage makes an angle 30° with the horizontal and side BC is vertical. The carriage lies on a fixed horizontal surface and is being pulled towards left with an horizontal acceleration 'a'. The magnitude of normal reactions exerted by sides AB and BC of carriage on the cylinder be N_{AB} and N_{BC} respectively. Neglect friction everywhere. Then as the magnitude of acceleration 'a' of the carriage is increased, pick up the correct statement:



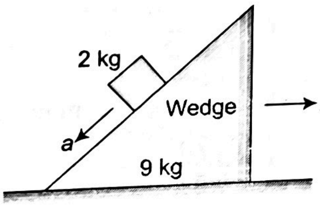
(a) N_{AB} increases and N_{BC} decreases.
(b) Both N_{AB} and N_{BC} increase.
(c) N_{AB} remains constant and N_{BC} increases.
(d) N_{AB} increases and N_{BC} remains constant.

107. A ball is suspended on a thread from the ceiling of a car. The brakes are applied and the speed of car changes from 5 m/sec to 5/3 m/sec during the time interval of 3 seconds. Find the angle that the thread with the ball will deviate from vertical.

(a) $\theta = \tan^{-1}\left(\frac{1}{9}\right)$ (b) $\theta = \tan^{-1}\left(\frac{8}{9}\right)$

(c) $\theta = \sin^{-1}\left(\frac{1}{9}\right)$ (d) $\theta = \cos^{-1}\left(\frac{1}{9}\right)$

108. A block of mass 2 kg slides down the face of a smooth 45° wedge of mass 9 kg as shown in figure. The wedge is placed on a frictionless horizontal surface. Determine the acceleration of the wedge.



(a) 2 m/s^2 (b) $\frac{11}{\sqrt{2}}$ m/s^2

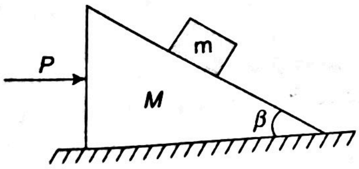
(c) 1 m/s^2 (d) none of these

109. A body of mass m is placed over a smooth inclined plane of inclination θ, which is placed over a lift which is moving up with an acceleration a_0. Base length of the inclined plane is L. Calculate the velocity of the block with respect to lift at the bottom, if it is allowed to slide down from the top of the plane from rest.

(a) $\sqrt{2(a_0+g)L\sin\theta}$ (b) $\sqrt{2(a_0+g)L\cos\theta}$

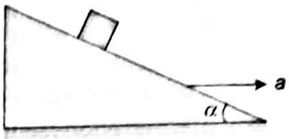
(c) $\sqrt{2(a_0+g)L\tan\theta}$ (d) $\sqrt{2(a_0+g)L\cot\theta}$

110. Two wooden blocks are moving on a smooth horizontal surface such that the mass m remains stationary with respect to block of mass M as shown in the figure. The magnitude of force P is:



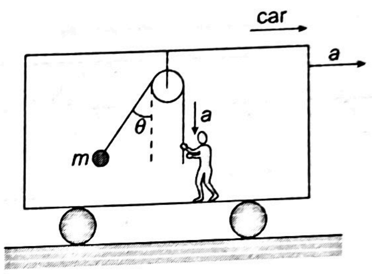
(a) $(M+m)g\tan\beta$ (b) $g\tan\beta$
(c) $mg\cos\beta$ (d) $(M+m)g\operatorname{cosec}\beta$

111. A block is kept on a frictionless inclined surface with angle of inclination 'α'. The incline is given an acceleration 'a' to keep the block stationary. Then a is equal to



(a) g (b) $g\tan\alpha$
(c) $g/\tan\alpha$ (d) $g\operatorname{cosec}\alpha$

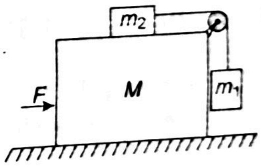
112. A bob is hanging over a pulley inside a car through a string. The second end of the string is in the hand of a person standing in the car. The car is moving with constant acceleration 'a' directed horizontally as shown in figure. Other end of the string is pulled with constant acceleration 'a' (relative to car) vertically. The tension in the string is equal to



(a) $m\sqrt{g^2+a^2}$ (b) $m\sqrt{g^2+a^2}-ma$

(c) $m\sqrt{g^2+a^2}+ma$ (d) $m(g+a)$

113. A large cubical shaped block of mass M rests on a fixed horizontal surface. Two blocks of mass m_1 and m_2 are connected by a light inextensible string passing over a light pulley as shown. Neglect friction everywhere. Then the constant horizontal force of magnitude F that should be applied to M so that m_1 and m_2 do not move relative to M is:



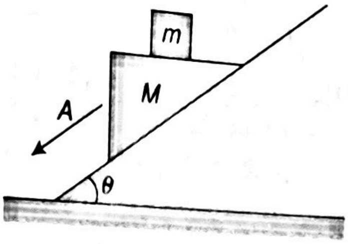
(a) $F = \frac{m_2}{m_1}(m_1+m_2+M)g$

(b) $F = \frac{m_1}{m_2}(m_1+m_2+M)g$

(c) $F = \frac{m_1}{m_2}(m_1+M)g$

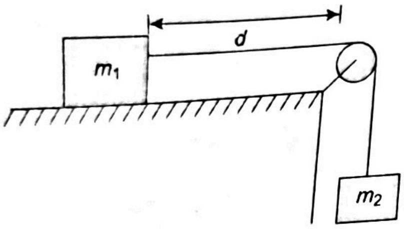
(d) $F = \frac{m_2}{m_1}(m_1+M)g$

114. A block of mass m is kept on a wedge of mass M. Initially the system is held. At certain time the system is released and the wedge is observed to move with acceleration A on inclined surface as shown. There is no friction anywhere. The acceleration of block (m) with respect to wedge (M) will be



(a) A rightward
(b) $A\cos\theta$ rightward
(c) $A\cos\theta$ leftward
(d) none of these

115. A block of mass m_1 lies on a smooth horizontal table and is connected to another freely hanging block of mass m_2 by a light inextensible string passing over a smooth fixed pulley situated at the edge of the table. Initially the system is at rest with m_1 a distance d from the pulley. Then the time taken for m_1 to reach the pulley is



(a) $\dfrac{m_2 g}{m_1+m_2}$
(b) $\sqrt{\dfrac{2d(m_1+m_2)}{m_2 g}}$
(c) $\sqrt{\dfrac{2m_2 d}{(m_1+m_2)g}}$
(d) None of these

Basic Concept of Static and Kinetic Frictions

116. A rectangular wooden block 5 cm × 10 cm × 10 cm in size is kept on a horizontal surface with its face of largest area on the surface. A minimum force of 1.5 N applied parallel to the surface sets the block in sliding motion along the surface. If the block is now kept with its face of smaller area in contact with the surface, the minimum force applied parallel to the surface, to set the block in motion, is

(a) greater than 1.5 N
(b) less than 1.5 N
(c) equal to 1.5 N
(d) may be greater or less than 1.5 N

117. A body of mass 2 kg is at rest on a horizontal table. The coefficient of friction between the body and the table is 0.3. A force of 5 N is applied on the body. The acceleration of the body is

(a) 0 ms^{-2}
(b) 2.5 ms^{-2}
(c) 5 ms^{-2}
(d) 7.5 ms^{-2}

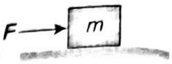
118. A body of mass 2 kg is at rest on a horizontal table. The coefficient of friction between the body and the table is 0.3. A force of 5 N is applied on the body. The force of friction is

(a) 5 N
(b) 5.88 N
(c) 6 N
(d) 20 N

119. A block of mass 3 kg is placed on a rough horizontal surface ($\mu_s = 0.4$). A force of 8.7 N is applied on the block. The force of friction between the block and floor is

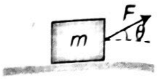
(a) 8.7 N
(b) 12 N
(c) 10 N
(d) zero

120. A horizontal force F acts on the block of mass m and the block remains stationary, the value of friction force is



(a) μmg
(b) $\mu mg - F$
(c) F
(d) zero

121. In previous question, if we pull the block by the force F making an angle θ and the block remains stationary, the value of friction force is

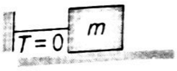


(a) μmg
(b) $F\cos\theta$
(c) $\dfrac{\mu mg}{\sin\theta+\mu\cos\theta}$
(d) $\dfrac{\mu mg}{\sqrt{1+\mu^2}}$

122. In Q. 120, the minimum force F required to pull it $\left(\mu=\dfrac{1}{2}\right)$ is:

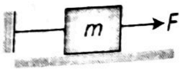
(a) $\dfrac{mg}{2}$
(b) $\dfrac{mg}{2}\cos\theta$
(c) $\dfrac{mg}{\sqrt{5}}$
(d) none of these

123. A block of mass m is stationary on a horizontal surface. It is connected with a string which has no tension. The coefficient of friction between the block and surface is m. Then, the frictional force between the block and surface is:



(a) zero
(b) μmg
(c) $\dfrac{mg}{\mu}$
(d) none of these

124. In previous question, if a horizontal force $F = \mu mg/2$ acts on the block and the block remains stationary, then tension in string is



(a) zero
(b) $\dfrac{3\mu mg}{2}$
(c) $\dfrac{\mu mg}{2}$
(d) none of these

125. A body of mass 2 kg is placed on a horizontal surface having kinetic friction 0.4 and static friction 0.5. If the force applied on the body is 2.5 N, then the frictional force acting on the body will be

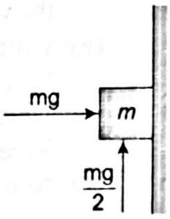
(a) 8 N (b) 10 N
(c) 20 N (d) 2.5 N

126. In previous question, if the force applied on the body is 20 N, the acceleration of the body will be
(a) 10 ms^{-2} (b) 6 ms^{-2}
(c) 5 ms^{-2} (d) 8.75 ms^{-2}

127. A rectangular body is held at rest by pressing it against a vertical wall for which $\mu < 1$. Which of the following is generally true?
(a) It will be easier to hold the body if the surfaces in contact are smooth.
(b) Pressing force required is smaller than weight mg of the body
(c) Pressing force required is greater than weight mg of the body
(d) The required pressing force is independent of coefficient of friction between surfaces in contact.

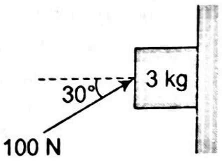
128. A block of weight W is held against a vertical wall by applying a horizontal force of 75 N. The surface of the wall is rough. Now, (consider $\mu < 1$)
(a) $W < 75$ N (b) $W = 75$ N
(c) $W > 75$ N (d) None of these

129. A block pressed against the vertical wall is in equilibrium. The minimum coefficient of friction is:
(a) 0.4
(b) 0.2
(c) 0.5
(d) none of these



130. In previous question, if $\mu = 0.3$, the acceleration of the block will be:
(a) zero (b) $\frac{g}{10}\uparrow$
(c) $\frac{g}{4}\downarrow$ (d) $\frac{g}{5}\downarrow$

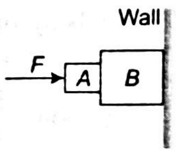
131. A force of 100 N is applied on a block of mass 3 kg as shown in the figure. The coefficient of friction between the surface and the block is $\mu = \frac{1}{\sqrt{3}}$. The frictional force acting on the block is



(a) 15 N downwards (b) 25 N upwards
(c) 20 N downwards (d) 30 N upwards

132. In previous problem the acceleration of block is
(a) zero (b) 10 m/s^2 upwards
(c) 10 m/s^2 downward (d) none of these

133. Figure shows two blocks A and B pushed against the wall with the force F. The wall is smooth but the surfaces in contact of A and B are rough. Which of the following is true for the system of blocks to be at rest against wall?



(a) F should be equal to weight of A and B
(b) F should be less than weight of A and B
(c) F should be more than weight of A and B
(d) System cannot be in equilibrium (at rest).

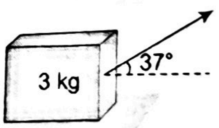
134. A block of mass 1 kg is at rest on a horizontal table. The coefficient of static friction between the block and the table is 0.5. The magnitude of the force acting upwards at an angle of 60° from the horizontal that will just start the block moving is
(a) 5 N (b) $\frac{20}{2+\sqrt{3}}$ N
(c) $\frac{20}{2-\sqrt{3}}$ N (d) 10 N

135. A box of mass m kg is placed on the rear side of an open truck accelerating at 4 ms^{-2}. The coefficient of friction between the box and the surface below it is 0.4. The net acceleration of the box with respect to the truck is zero. The value of m is
(a) 4 kg (b) 8 kg
(c) 9.78 kg (d) It could be any value

136. A body of mass 8 kg lies on a rough horizontal table. It is observed that a certain horizontal force gives the body an acceleration of 4 ms^{-2}. When this force is doubled, the acceleration of the body is 16 ms^{-2}. The coefficient of friction is
(a) 0.2 (b) 0.3
(c) 0.4 (d) 0.8

137. A body of mass 40 kg resting on a rough horizontal surface is subjected to a force P which is just enough to start the motion of the body. If $\mu_s = 0.5$ $\mu_k = 0.4$, $g = 10$ ms^{-2} and the force P is continuously applied on the body, then the acceleration of the body is
(a) zero (b) 1 ms^{-2}
(c) 2 ms^{-2} (d) 2.4 ms^{-2}

138. A 3 kg block is pulled by a force which is inclined at 37° to the horizontal table. The friction coefficient between the table and block is 1/3. For what minimum value of this force, will the block start sliding?



(a) 5 N (b) 10 N
(c) 20 N (d) 25 N

139. A block of mass m is placed in equilibrium on a moving plank. The maximum horizontal acceleration of the plank for $\mu = 0.2$ is:
(a) 2 m/s^2 (b) 3 m/s^2
(c) dependent on the mass m (d) none of these

140. A block of mass $m = 2$ kg is placed in equilibrium on a moving plank accelerating with acceleration $a = 4\ m/s^2$. If coefficient of friction between plank and block $\mu = 0.2$. The frictional force acting on the block is:

(a) 8 N
(b) 6 N
(c) zero
(d) 4 N

141. A block of mass $m = 2$ kg is placed in equilibrium on a moving plank accelerating with acceleration $a = 1\ m/s^2$. If coefficient of friction between plank and block $\mu = 0.2$. The frictional force acting on the block is:

(a) 2 N
(b) 4 N
(c) 3 N
(d) None of these

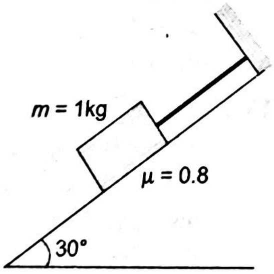
142. A block of mass 70 kg is kept on a rough horizontal surface ($\mu = 0.4$). A person is trying to pull the block by applying a horizontal force , but the block is not moving. The net contact force exerted by the surface on the block is F, then:

(a) $F = 700$ N
(b) $F = 280$ N
(c) $700\ N \le F \le 754\ N$
(d) $F = 754$ N

143. A block of mass 2 kg rests on a rough inclined plane making an angle of 30° with the horizontal. The coefficient of static friction between the block and the plane is 0.7. The frictional force on the block is

(a) 10 N
(b) $7\sqrt{3}$ N
(c) $10 \times \sqrt{3}$ N
(d) 7 N

144. For the arrangement shown in the fig. the tension in the string is [Given: $\tan^{-1}(0.8) = 39°$].



(a) 6 N
(b) 6.4 N
(c) 0.4 N
(d) zero

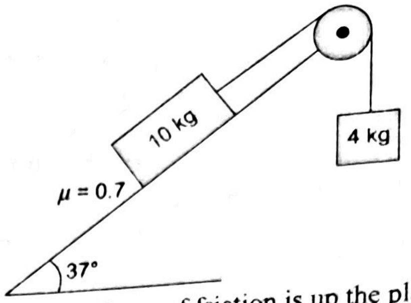
145. A block of mass 4 kg rests on an inclined plane. The inclination of the plane is gradually increased. It is found that when the inclination is 3 in 5 $\left(\sin\theta = \frac{3}{5}\right)$, the block just begins to slide down the plane. The coefficient of friction between the block and the plane is

(a) 0.4
(b) 0.6
(c) 0.8
(d) 0.75

146. A block of mass 'm' is placed on a rough inclined plane. When the inclination of the plane is θ, the block just begins to slide down the plane under its own weight. The minimum force applied parallel to the plane, to move the block up the plane, is

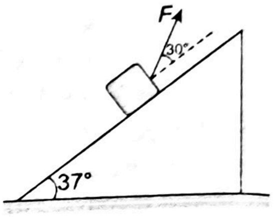
(a) $mg \sin\theta$
(b) $2mg \sin\theta$
(c) $mg \cos\theta$
(d) $mg \tan\theta$

147. In the arrangement shown in the figure [$\sin 37° = 3/5$]



(a) direction of force of friction is up the plane
(b) the magnitude of force of friction is zero
(c) the tension in the string is 20 N
(d) magnitude of force of friction is 56 N

148. A block of mass $m = 4$ kg is placed over a rough inclined plane as shown in figure. The coefficient of friction between the block and the plane is $\mu = 0.5$. A force $F = 10$ N is applied on the block at an angle of 30°. The friction force between the block and wedge is

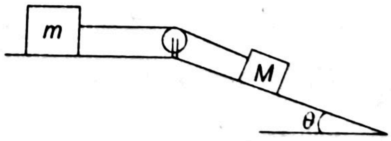


(a) static in nature in the direction up the plane and have the value 30.2 N
(b) static in nature in the direction down the plane and have the value 30.2 N
(c) kinetic in nature in the direction up the plane and have the value 13.5 N
(d) None of these

149. A block of mass m remains stationary on a fixed inclined plane of inclination θ. If μ = coefficient of static friction, the reaction of ground on the block is:

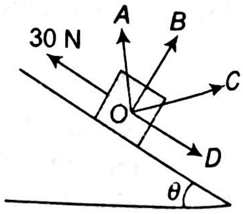
(a) $\mu mg \cos\theta$ ↖
(b) $mg \cos\theta$ ↗
(c) $mg \sin\theta$ ↖
(d) mg ↓

150. Find the maximum value of (M/m) in the situation shown in figure so that the system remains at rest. Friction coefficient of both the contacts is μ, string is massless and pulley is friction less.



(a) $\dfrac{\cos\theta}{\sin\theta - \mu\cos\theta}$
(b) $\dfrac{\sin\theta}{\sin\theta - \mu\cos\theta}$
(c) $\dfrac{\mu\cos\theta}{\sin\theta - \mu\cos\theta}$
(d) $\dfrac{\mu}{\sin\theta - \mu\cos\theta}$

151. A body of mass 10 kg lies on a rough inclined plane of inclination $\theta = \sin^{-1}\frac{3}{5}$ with the horizontal. When a force of 30 N is applied



on the block parallel to and upward the plane, the total reaction by the plane on the block is nearly along:

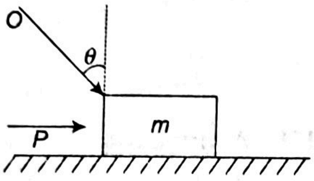
(a) OA (b) OB

(c) OC (d) OD

152. A small mass slides down an inclined plane of inclination θ with the horizontal. The coefficient of friction is $\mu = \mu_0 x$ where x is the distance through which the mass slides down and μ_0, a constant. Then the speed is maximum after the mass covers a distance of

(a) $\frac{\cos\theta}{\mu_0}$ (b) $\frac{\sin\theta}{\mu_0}$

(c) $\frac{\tan\theta}{\mu_0}$ (d) $\frac{2\tan\theta}{\mu_0}$



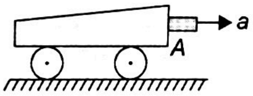
153. A block of mass m, lying on a horizontal plane, is acted upon by a horizontal force P and another force Q, inclined at an angle θ to the vertical. The block will remain in equilibrium, if the coefficient of friction between it and the surface is:

(a) $(P + Q\sin\theta)/(mg + Q\cos\theta)$

(b) $(P\cos\theta + Q)/\text{mg} - Q\sin\theta)$

(c) $(P + Q\cos\theta)/(mg + Q\sin\theta)$

(d) $(P\sin\theta - Q) - (mg - Q\cos\theta)$



154. The minimum acceleration that must be imparted to the cart in the figure so that the block A will not fall (given μ is the coefficient of friction between the surfaces of block and cart) is given by:

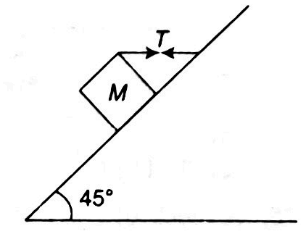
(a) μg (b) g/μ

(c) $\frac{g}{\sqrt{\mu}}$ (d) $\frac{\mu}{g}$

155. A particle is projected along the line of greatest slope up a rough plane inclined at an angle of 45° with the horizontal. If the coefficient of friction is 1/2. their retardation is:

(a) $\frac{g}{2\sqrt{2}}$ (b) $\frac{g}{\sqrt{2}}$

(c) $\frac{g}{\sqrt{2}}\left(1-\frac{1}{2}\right)$ (d) $\frac{g}{\sqrt{2}}\left(1+\frac{1}{2}\right)$



156. A block of mass 15 kg is resting on a rough inclined plane as shown in figure. The block is tied by a horizontal string which has a tension of 50 N. The coefficient of friction between the surfaces of contact is:

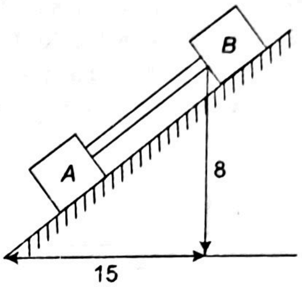
(a) 1/2 (b) 2/3

(c) 3/4 (d) 1/4

157. A horizontal force, just sufficient to move a body of mass 4 kg lying on a rough horizontal surface, is applied on it. The coefficient of static and kinetic friction between the body and the surface are 0.8 and 0.6 respectively. If the force continues to act even after the block has started moving, the acceleration of the block in m/s^2 is ($g = 10$ m/s^2).

(a) 1/4 (b) 1/2

(c) 2 (d) 4

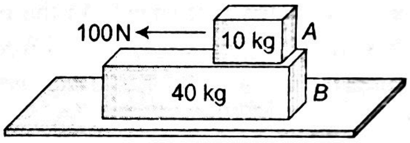


158. Blocks A and B in the figure are connected by a bar of negligible weight. Mass of each block is 170 kg and $\mu_A = 0.2$ and $\mu_B = 0.4$, where μ_A and μ_B are the coefficients of limiting friction between blocks and plane, calculate the force developed in the bar ($g = 10$ m/sec^2):

(a) 150 N (b) 75 N

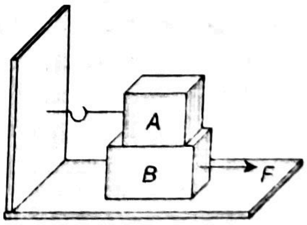
(c) 200 N (d) 250 N

159. A 40 kg slab rests on a frictionless floor as shown in the figure. A 10 kg block rests on the top of the slab. The static coefficient of friction between the block and slab is 0.60 while the kinetic friction is 0.40. The 10 kg block is acted upon by a horizontal force 100 N. If $g = 9.8$ m/s^2, the resulting acceleration of the slab will be



(a) 1 m/s^2 (b) 1.5 m/s^2

(c) 2 m/s^2 (d) 6 m/s^2



160. A block A with mass 100 kg is resting on another block B of mass 200 kg. As shown in figure a horizontal rope tied to a wall holds it. The coefficient of friction between A and B is 0.2 while coefficient of friction between B and the ground is 0.3. The minimum required force F to start moving B will be

(a) 900 N (b) 100 N

(c) 1100 N (d) 1200 N

Dynamics of Circular Motion

161. An unbanked curve has a radius of 60 m. The maximum speed at which a car can make a turn if the coefficient of static friction is 0.75, is

(a) 2.1m/s (b) 14 m/s

(c) 21 m/s (d) 7 m/s

2. A person wants to drive on the vertical surface of a large cylindrical wooden 'well' commonly known as 'death well' in a circus. The radius of the well is 2 meter, and the coefficient of friction between the tyres of the motorcycle and the wall of the well is 0.2, the minimum speed the motorcyclist must have in order to prevent slipping should be

(a) 10 m/s (b) 15 m/s
(c) 20 m/s (d) 25 m/s

163. Water in a bucket is whirled in a vertical circle with a string attached to it. The water does not fall down even when the bucket is inverted at the top of its path. We conclude that in this position

(a) $mg = \frac{mv^2}{r}$

(b) mg is greater than $\frac{mv^2}{r}$

(c) mg is not greater than $\frac{mv^2}{r}$

(d) none of these

164. A stone of mass m tied to a string of length l is rotated in a circle with the other end of the string as the centre. The speed of the stone is v. If the string breaks, the stone will move

(a) towards the centre (b) away from the centre
(c) along a tangent (d) will stop

165. A motorcycle is going on an overbridge of radius R. The driver maintains a constant speed. As the motorcycle is ascending on the overbridge, the normal force on it

(a) Increases (b) Decreases
(c) Remains the same (d) Fluctuates

166. Three identical cars A, B and C are moving at the same speed on three bridges. The car A goes on a plane bridge, B on a bridge convex upward and C goes on a bridge concave upward. Let F_A, F_B and F_C be the normal forces exerted by the cars on the bridges when they are at the middle of bridges.

(a) F_A is maximum of the three forces.
(b) F_B is maximum of the three forces.
(c) F_C is maximum of the three forces.
(d) $F_A = F_B = F_C$

167. A train A runs from east to west and another train B of the same mass runs from west to east at the same speed along the equator. A presses the track with a force F_1 and B presses the track with a force F_2.

(a) $F_1 > F_2$
(b) $F_1 < F_2$
(c) $F_1 = F_2$
(d) The information is insufficient to find the relation between F_1 and F_2

168. A car turns a corner on a slippery road at a constant speed of 12 m/s. If the coefficient of friction is 0.4, the minimum radius of the arc in metres in which the car turns is

(a) 72 (b) 36
(c) 18 (d) 9

169. A small object placed on a rotating horizontal turn table just slips when it is placed at a distance 4 cm from the axis of rotation. If the angular velocity of the turn-table is doubled, the object slips when its distance from the axis of rotation is

(a) 1 cm (b) 2 cm
(c) 4 cm (d) 8 cm

170. An automobile of mass m is crossing over a convex upwards over bridge with a speed v. If the radius of the bridge is r, the thrust on the bridge at the highest point will be

(a) $mg + \frac{mv^2}{r}$ (b) $mg - \frac{mv^2}{r}$

(c) mg (d) $\frac{mv^2}{r}$

171. A curved road of 50 m in radius is banked to correct angle for a given speed. If the speed is to be doubled keeping the same banking angle, the radius of curvature of the road should be changed to

(a) 200 m (b) 100 m
(c) 50 m (d) none of these

172. A stone of mass m is tied to a string and is moved in a vertical circle of radius r making n revolutions per minute. The total tension in the string when the stone is at its lowest point is

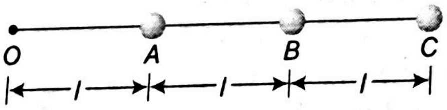
(a) mg (b) $m(g + \pi nr^2)$

(c) $m(g + nr)$ (d) $m\left(g + \frac{\pi^2 n^2 r}{900}\right)$

173. A stone tied to a string is rotated with a uniform speed in a vertical plane. If mass of the stone is m, length of the string is r and linear speed of the stone is v, then tension in the string when the stone is at its lowest point is

(a) mg (b) mv^2/r
(c) $(mv^2/r) - mg$ (d) $(mv^2/r) + mg$

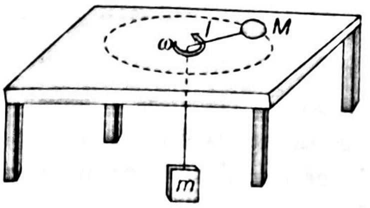
174. Three identical particles are joined together by a thread as shown in figure. All the three particles are moving in a horizontal plane. If the velocity of the outermost particle is v_0, then the ratio of tensions in the three sections of the string is



(a) 3 : 5 : 7 (b) 3 : 4 : 5
(c) 7 : 11 : 6 (d) 3 : 5 : 6

175. A block of mass M is situated on a smooth horizontal frictionless table. A thread tied to the block passes through a hole in the table and carries a mass m at its other end. If the length of the thread above the table is l, what should

be the value of m so that it may remain suspended at a constant height and the block M moves in a circular path with an angular velocity ω on the table?



(a) $\frac{Ml\omega^2}{g}$ (b) $\frac{Ml\omega^2}{3g}$

(c) $\frac{Ml\omega^2}{5g}$ (d) $\frac{2Ml\omega^2}{g}$

176. A string of length $l = 1$ m is fixed at one end and carries a mass of 100 gm at other end. The string makes $\sqrt{5}/\pi$ revolutions per second about a vertical axis passing through its second end. What is the angle of inclination of the string with the vertical?

(a) 30° (b) 45°

(c) 60° (d) 75°

177. A stone of mass 1 kg tied to a light inextensible string of length $L = 10$ m is whirling in a circular path of radius L in vertical plane. If the ratio of the maximum tension in the string to the minimum tension in the string is 4 and if g is taken to be 10 ms^{-2}, the speed of the stone at the highest point of the circle is

(a) 10 ms^{-1} (b) $5\sqrt{2}$ ms^{-1}

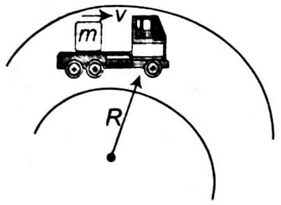
(c) $10\sqrt{3}$ (d) None of these

178. A 8 kg stone tied at the end of a string 1 metre long is whirled in a vertical circle. At the instant when the string makes an angle θ with the vertical, the speed of the stone is 4ms^{-1} and the tension in the thread is 104 N. Then θ is

(a) 0° (b) 30°

(c) 60° (d) None of these

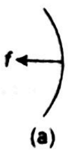
179. A truck is carry a box of mass $m = 50$ kg on its flat horizontal rough surface with coefficient of friction $\mu = 0.3$. It is crossing a circular track of radius 27 m. What is the maximum speed of the truck so that the box does not slide from the truck while moving on the circular path?



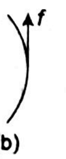
(a) 18 km/hr (b) 36 km/hr

(c) 32.4 km/hr (d) None of these

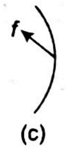
180. Indicate the direction of frictional force on a car which is moving along the curved path with non zero tangential acceleration; in anti-clock direction:



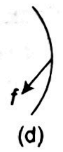
(a)



(b)



(c)



(d)

181. A particle of mass m is attached to a massless string of length l and is oscillating in a vertical plane with the other end of the string fixed to a rigid support. The tension in the string at a certain instant is $T = k$ mg.

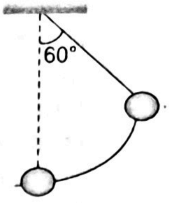
(a) k can never be greater than 1

(b) k can never be less than 1

(c) k can never be equal to 1

(d) k can never be greater than 3

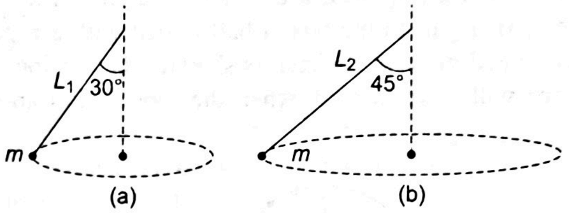
182. A pendulum of length $l = 1$ m is released from $\theta_0 = 60°$. The rate of change of speed of the bob at $\theta = 30°$ is ($g = 10$ m/s^2)



(a) $5\sqrt{3}$ m/s^2 (b) 5 m/s^2

(c) 10 m/s^2 (d) 2.5 m/s^2

183. Two particles tied to different strings are whirled in a horizontal circle as shown in figure. The ratio of lengths of the strings so that they complete their circular path with equal time period is:

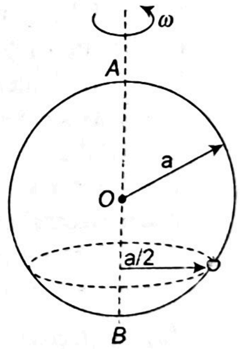


(a) (b)

(a) $\sqrt{\frac{3}{2}}$ (b) $\sqrt{\frac{2}{3}}$

(c) 1 (d) None of these

184. A smooth wire is bent into a vertical circle of radius a. A bead P can slide smoothly on the wire. The circle is rotated about vertical diameter AB as axis with a speed ω as shown in figure. The bead P is at rest w.r.t. the circular ring in the position shown. Then ω^2 is equal to:



(a) $\frac{2g}{a}$

(b) $\frac{2g}{a\sqrt{3}}$

(c) $\frac{g\sqrt{3}}{a}$

(d) $\frac{2a}{g\sqrt{3}}$

185. A particle is attached to an end of a rigid rod. The other end of the rod is hinged and the rod rotates always remaining horizontal. Its angular speed is increasing at constant rate. The mass of the particle is 'm'. The force exerted by the rod on the particle is $\vec{F}$, then:

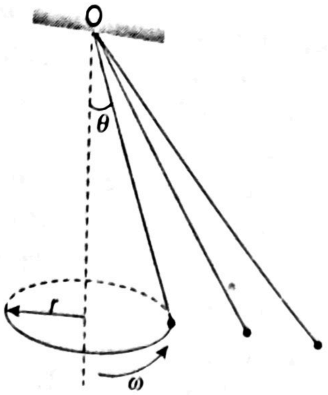
(a) $F \geq$ mg

(b) F is constant

(c) The angle between $\vec{F}$ and horizontal plane decreases.

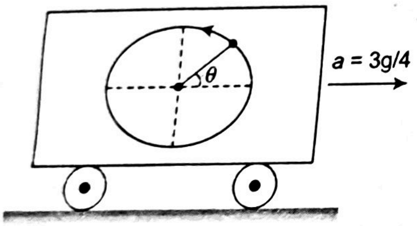
(d) The angle between $\vec{F}$ and the rod decreases

186. Three masses of small size are attached by light inextensible strings of various lengths to a point O on the ceiling. All of the masses swing round in horizontal circles of various radii with the same angular frequency ω (one such circle is drawn in the shown figure.) Then pick up the correct statement.



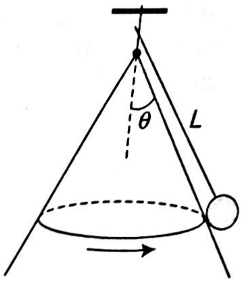
(a) The vertical depth of each mass below point of suspension from ceiling is different.
(b) The radius of horizontal circular path of each mass is same.
(c) All masses revolve in the same horizontal plane.
(d) All the particles must have same mass.

187. A bus is moving with a constant acceleration $a = 3g/4$ towards right. In the bus, a ball is tied with a rope and is rotated in vertical circle as shown. The tension in the rope will be minimum, when the rope makes an angle θ = ______.



(a) 53°
(b) 37°
(c) 180 – 53°
(d) 180 + 37°

188. A small sized mass m is attached by a massless string (of length L) to the top of a fixed frictionless solid cone whose axis is vertical. The half angle at the vertex of the cone is θ. If the mass m moves around in a horizontal circle at speed v, what is the maximum value of v for which mass stays in contact with the cone? (g is acceleration due to gravity.)



(a) $\sqrt{gL \cos\theta}$
(b) $\sqrt{gL \sin\theta}$
(c) $\sqrt{gL \sin\theta \tan\theta}$
(d) $\sqrt{gL \tan\theta}$

189. A circular road of radius R is banked for a speed v = 40 km/hr. A car of mass m attempts to go on the circular road, the friction coefficient between the tyre and road is negligible:

(a) the car cannot make a turn without skidding
(b) if the car runs at a speed less than 40 km/hr, it will slip up the slope
(c) if the car runs at the correct speed of 40 km/hr, the force by the road on the car is equal to mv^2/r
(d) if the car runs at the correct speed of 40 km/hr, the force by the road on the car is greater than mg as well as greater than mv^2/r

190. A particle describes a horizontal circle in a conical funnel whose inner surface is smooth with speed of 0.5 m/s. What is the height of the plane of circle from vertex of the funnel?

(a) 0.25 cm
(b) 2 cm
(c) 4 cm
(d) 2.5 cm

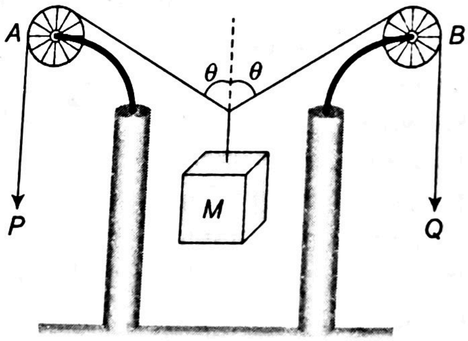
191. A stone of mass m tied to the end of a string revolves in a vertical circle of radius R. The net forces at the lowest and highest points of the circle directed vertically downwards are

(a) $mg - T_1$ and $mg + T_2$
(b) $mg + T_1$ and $mg - T_2$
(c) $mg + T_1 - \left(\frac{mv_1^2}{R}\right)$ and $mg - T_2 + \left(\frac{mv_2^2}{R}\right)$
(d) $mg - T_1 - \left(\frac{mv_1^2}{R}\right)$ and $mg + T_2 + \left(\frac{mv_2^2}{R}\right)$

(T_1 and n_1 denote the tension and speed at the lowest point. T_2 and v_2 denote corresponding values at the highest point.)

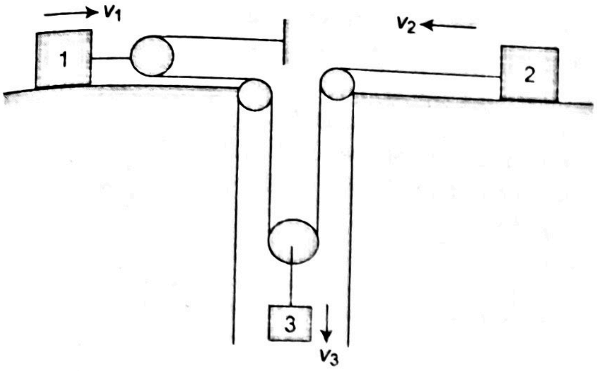
Problems Based on Mixed Concepts

192. In the arrangement shown in figure the ends P and Q of an non-stretchable string move downwards with uniform speed U. Pulleys A and B are fixed. Mass M moves upwards with a speed



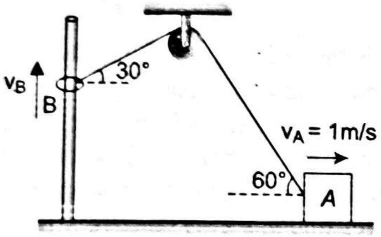
(a) $2U \cos\theta$
(b) $U \cos\theta$
(c) $\frac{2U}{\cos\theta}$
(d) $\frac{U}{\cos\theta}$

193. Three blocks 1, 2 and 3 are arranged as shown in the figure. The velocities of the blocks v_1, v_2 and v_3 are shown in the figure. What is the relationship between v_1, v_2 and v_3?



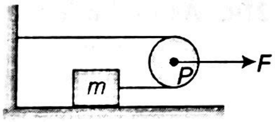
(a) $2v_1 + v_2 = v_3$ (b) $v_1 + v_2 = v_3$
(c) $v_1 + 2v_2 = v_3$ (d) None of these

194. Find velocity of ring B (V_B) at the instant shown. The string is taut and inextensible:



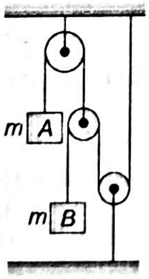
(a) $\frac{1}{2}$ m/s (b) $\frac{\sqrt{3}}{4}$ m/s
(c) $\frac{1}{4}$ m/s (d) 1 m/s

195. The ratio of acceleration of pulley to the acceleration of the block is (string is inextensible)



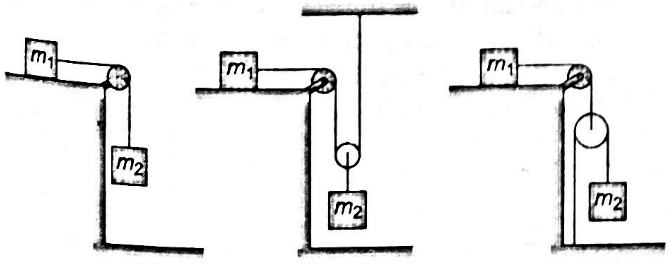
(a) 0.5
(b) 2
(c) 1 (d) None of these

196. In the arrangement shown, the pulleys and the strings are ideal. The acceleration of block B is



(a) $g/5$ (b) $g/2$
(c) $2g/5$ (d) $2g/3$

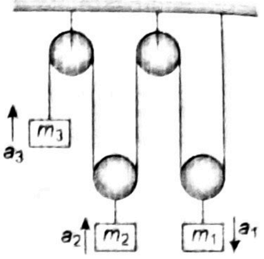
197. In each of the three arrangements, the block of mass m_1 is being pulled left with constant velocity. There is no friction anywhere. The strings are light and inextensible and pulleys are massless. The ratio of the speed of the block of mass m_2 in the three cases respectively is:



(a) (b) (c)

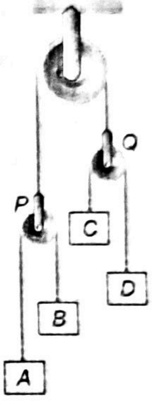
(a) 2 : 1 : 4 (b) 2 : 4 : 1
(c) 4 : 2 : 1 (d) Cannot be calculated

198. If the blocks are moving as shown in the figure the relation between a_1, a_2 and a_3 will be



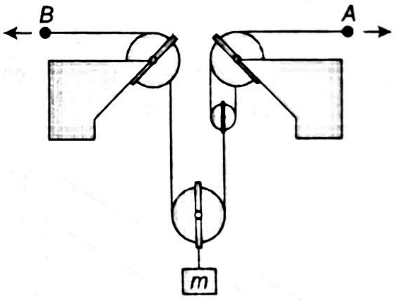
(a) $2a_1 + 2a_2 + a_3 = 0$
(b) $2a_1 - 2a_2 + a_3 = 0$
(c) $2a_1 - 2a_2 - a_3 = 0$
(d) $2a_2 - 2a_1 + a_3 = 0$

199. In the figure acceleration of A is 1 m/s^2 upwards, acceleration of B is 7 m/s^2 upwards and acceleration of C is 2 m/s^2 upwards. The acceleration of D will be



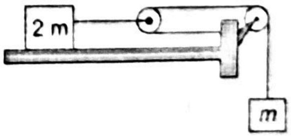
(a) 7 m/s^2 downwards
(b) 2 m/s^2 downwards
(c) 10 m/s^2 downwards
(d) 8 m/s^2 downwards

200. For the pulley system shown, each of the cables at A and B is given a velocity of 2 m/s in the direction of the arrow. Determine the upward velocity v of the load m.



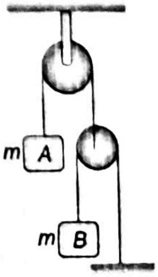
(a) 1.5 m/s (b) 3 m/s
(c) 6 m/s (d) None of these

201. Consider the situation shown in figure. All the surfaces are smooth. The tension in the string connected to 2 m is



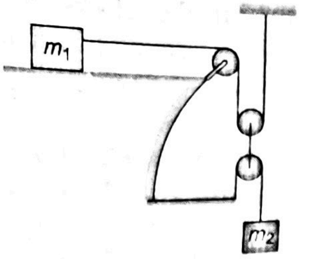
(a) $\frac{mg}{3}$ (b) $\frac{4mg}{3}$
(c) $\frac{2mg}{3}$ (d) mg

202. In the figure shown neglecting friction and mass of pulleys, what is the acceleration of mass B?



(a) $\frac{g}{3}$ (b) $\frac{5g}{2}$
(c) $\frac{2g}{2}$ (d) $\frac{2g}{5}$

Two blocks of masses m_1 and m_2 are connected as shown in the figure. The acceleration of the block m_2 is:



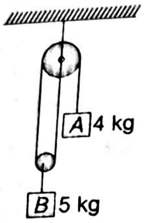
(a) $\frac{m_2 g}{m_1 + m_2}$

(b) $\frac{m_1 g}{m_1 + m_2}$

(c) $\frac{4m_2 g - m_1 g}{m_1 + m_2}$

(d) $\frac{m_2 g}{m_1 + 4m_2}$

204. The acceleration of the blocks (A) and (B) respectively in situation shown in the figure is: (pulleys and strings are massless)



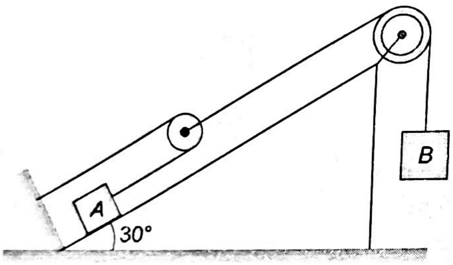
(a) $\frac{2g}{7}$ downward, $\frac{g}{7}$ upward

(b) $\frac{2g}{3}$ downward, $\frac{g}{3}$ upward

(c) $\frac{10}{13}g$ downward, $\frac{5g}{13}$ upward

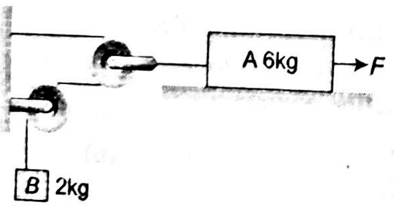
(d) none of these

205. In the system shown in figure $m_B = 4$ kg, and $m_A = 2$ kg. The pulleys are massless and friction is absent everywhere. The acceleration of block A is



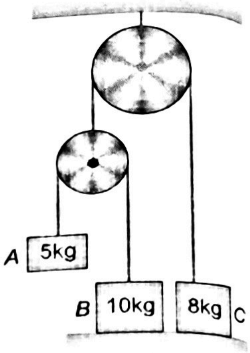
(a) 10/3 m/s^2
(b) 20/3 m/s^2
(c) 2 m/s^2
(d) 4 m/s^2

206. The system starts from rest and A attains a velocity of 5 m/s after it has moved 5 m towards right. Assuming the arrangement to be frictionless everywhere and pulley and strings to be light, the value of the constant force F applied on A is:



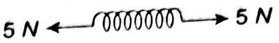
(a) 50 N
(b) 75 N
(c) 100 N
(d) 96 N

207. In the following arrangement the system is initially at rest. The 5 kg block is now released. Assuming the pulleys and string to be massless and smooth, the acceleration of block 'C' will be



(a) Zero
(b) 2.5 m/s^2
(c) $\frac{10}{7}$ m/s^2
(d) $\frac{5}{7}$ m/s^2

208. The tension in the spring is

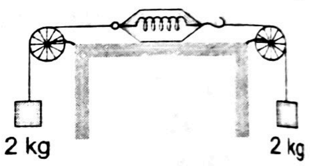


(a) Zero
(b) 2.5 N
(c) 5 N
(d) 10 N

209. A spring balance and a physical balance are kept in a lift. In these balances equal masses are placed. If now the lift starts moving upwards with constant acceleration, then

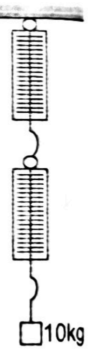
(a) The reading of spring balance will increase and the equilibrium position of the physical balance will disturb
(b) The reading of spring balance will remain unchanged and physical balance will remain in equilibrium
(c) The reading of spring balance will decrease and physical balance will remain in equilibrium
(d) The reading of spring balance will increase and the physical balance will remain in equilibrium

210. As shown in the figure, two equal masses each of 2 kg are suspended from a spring balance. The reading of the spring balance will be



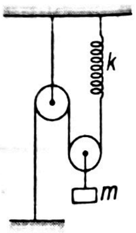
(a) Zero
(b) 2 kg
(c) 4 kg
(d) Between zero and 2 kg

211. A block of mass 10 kg is suspended through two light spring balances as shown in figure.



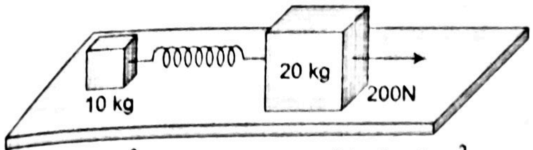
(a) Both the scales will read 10 kg
(b) Both the scales will read 5 kg.
(c) The upper scale will read 10 kg and the lower zero
(d) The readings may be anything but their sum will be 10 kg

212. Mass m shown in the figure is in equilibrium. If it is displaced further by x and released find its acceleration just after it is released. Take pulleys to be light and smooth and strings light.



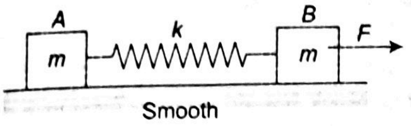
(a) $\frac{4kx}{5m}$
(b) $\frac{2kx}{5m}$
(c) $\frac{4kx}{m}$
(d) none of these

213. The masses of 10 kg and 20 kg respectively are connected by a massless spring as shown in figure. A force of 200 N acts on the 20 kg mass. At the instant shown, the 10 kg mass has acceleration 12 m/sec^2. What is the acceleration of 20 kg mass?



(a) 12 m/sec^2 (b) 4 m/sec^2
(c) 10 m/sec^2 (d) Zero

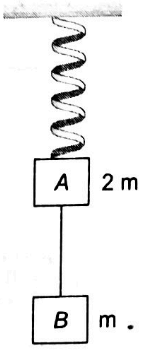
214. Initially the spring is undeformed. Now the force 'F' is applied to 'B' as shown in the figure. When the displacement of 'B' w.r.t. 'A' is 'x' towards right in some time then the relative acceleration of 'B' w.r.t. 'A' at that moment is:



(a) $\frac{F}{2m}$ (b) $\frac{F-kx}{m}$
(c) $\frac{F-2kx}{m}$ (d) none of these

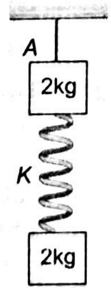
215. Two blocks A and B of masses $2m$ and m, respectively are connected by a massless and inextensible string. The whole system is suspended by a massless spring as shown in the figure. The magnitudes of acceleration of A and B immediately after the string is cut, are respectively:

(a) $g, \frac{g}{2}$
(b) $\frac{g}{2}, g$
(c) g, g
(d) $\frac{g}{2}, \frac{g}{2}$



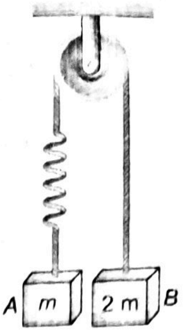
216. Two blocks of mass 2 kg are connected by a massless ideal spring of spring constant $K = 10$ N/m. The upper block is suspended from roof by a light string A. The system shown is in equilibrium. The string A is now cut, the acceleration of upper block just after the string A is cut will be ($g = 10$ m/s^2)

(a) 0 m/s^2 (b) 10 m/s^2
(c) 15 m/s^2 (d) 20 m/s^2



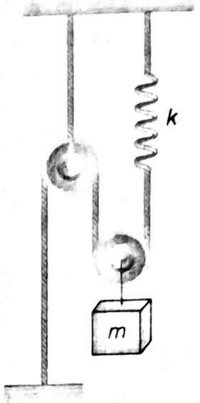
217. A block 'A' of mass 'm' is attached at one end of a light spring and the other end of the spring is connected to another block 'B' of mass 2 m through a light string as shown in the figure. 'A' is held and B is in static equilibrium. Now A is released. The acceleration of A just after that instant is 'a'. In the next case, B is held and A is in static equilibrium. Now when B is released, its acceleration immediately after the release is 'b'. The value of a/b is: (Pulley, string and the spring are massless)

(a) 0
(b) undefined
(c) 2
(d) $\frac{1}{2}$

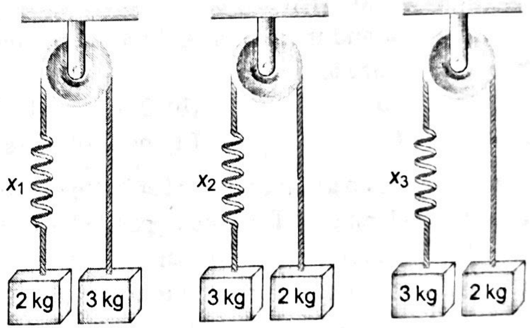


218. A block of mass m shown in figure is in equilibrium. If it is displaced further by x and released find its acceleration just after it is released. Take pulleys to be light and smooth and strings light.

(a) $\frac{4kx}{5m}$
(b) $\frac{2kx}{5m}$
(c) $\frac{4kx}{m}$
(d) none of these

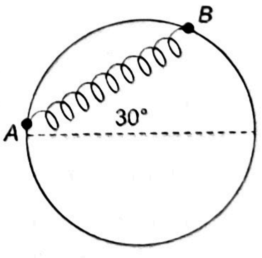


219. Same spring is attached with 2 kg, 3 kg and 1 kg blocks in three different cases as shown in figure. If x_1, x_2 and x_3 be the extensions in the spring in these cases then (Assume all the blocks to move with uniform acceleration)



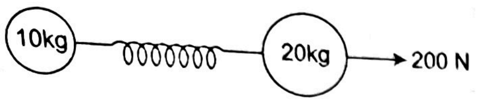
(a) $x_1 = 0, x_3 > x_2$ (b) $x_2 > x_1 > x_3$
(c) $x_3 > x_1 > x_2$ (d) $x_1 > x_2 > x_3$

220. A bead of mass m is attached to one end of a spring of natural length R and spring constant $K = \frac{(\sqrt{3}+1)mg}{R}$. The other end of the spring is fixed at a point A on a smooth vertical ring of radius R as shown in the figure. The normal reaction at B just after it is released to move is:



(a) $mg/2$ (b) $\sqrt{3}\,mg$
(c) $3\sqrt{3}\,mg$ (d) $\frac{3\sqrt{3}\,mg}{2}$

221. Two masses of 10 kg and 20 kg respectively are tied together by a massless spring. A force of 200 N is applied on a 20 kg mass as shown in figure. At the instant shown, the acceleration of 10 kg mass is 12 m/s^2, the acceleration of 20 kg mass is

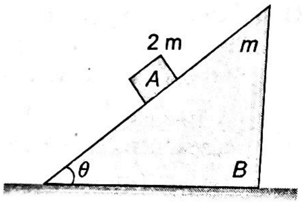


(a) 0
(b) 10 m/s^2
(c) 4 m/s^2
(d) 12 m/s^2

222. A horizontal force F of variable magnitude and constant direction acts on a body of mass m which is initially at rest at a point O on a smooth horizontal surface. The magnitude of F is given by $F = \beta + \alpha t$ where t is the time for which the force has been acting on the body and α and β are positive constants. If s is the distance of the body from O at time t, then s is equal to

(a) $\frac{1}{2m}(\beta t + \alpha t^2)t$
(b) $\frac{1}{2m}(\beta + \alpha t^2)$
(c) $\frac{(\beta + \alpha t)t^2}{2m}$
(d) $\frac{t^2}{6m}(3\beta + \alpha t)$

223. In the figure if block A and wedge B will move with same acceleration, then the magnitude of normal reaction between the block and the wedge will be (There is no friction between block and the wedge and the wedge moves on horizontal surface as shown.)

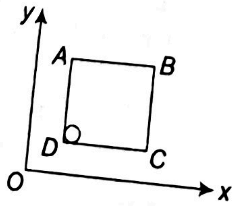


(a) 2 mg/cos θ
(b) 2 mg cos θ
(c) mg cos θ
(d) none of these

224. A car is moving on a plane inclined at 30° to the horizontal with an acceleration of 10 m/s^2 parallel to the plane upward. A bob is suspended by a string from the roof. The angle in degrees which the string makes with the vertical is: (Assume that the bob does not move relative to car) [$g = 10$ m/s^2]

(a) 20°
(b) 30°
(c) 45°
(d) 60°

225. A solid sphere of mass 2 kg is resting inside a cube as shown in the figure. The cube is moving with a velocity $v = (5t\hat{i} + 2t\hat{j})$m/s. Here t is the time in second. All surface are smooth. The sphere is at rest with respect to the cube. What is the total force exerted by the sphere on the cube? (Take $g = 10$ m/s^2)

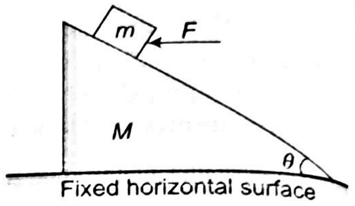


(a) $\sqrt{29}$ N
(b) 29 N
(c) 26 N
(d) $\sqrt{89}$ N

226. A lift of total mass M is raised by cables from rest through a height h. The greatest tension which the cables can safely bear is n Mg. The maximum sped of lift during its journey if the ascent is to made in shortest time is

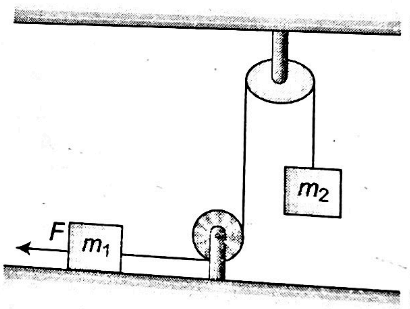
(a) $\sqrt{2gh\left(\frac{n+1}{n}\right)}$
(b) $\sqrt{2gh}$
(c) $\sqrt{2gh\left(\frac{n}{n+1}\right)}$
(d) $\sqrt{2gh\left(\frac{n-1}{n}\right)}$

227. A block of mass m lies on wedge of mass M, which lies on fixed horizontal surface. The wedge is free to move on the horizontal surface. A horizontal force of magnitude F is applied on block as shown, neglecting friction at all surfaces, the value of force F such that block has no relative motion w.e.t wedge will be: (where g is acceleration due to gravity)

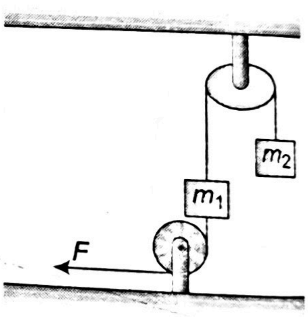


(a) $(M + m)g$ tan θ
(b) $(M + m)g$ cot θ
(c) $\frac{m}{M}(M + m)\ g$ tan θ
(d) $\frac{m}{M}(M + m)\ g$ cot θ

228. The ratio of tensions in the string connected to the block of mass m_2 in figure-(i) and figure-(ii) respectively is (friction is absent everywhere): [$m_1 = 50$ kg, $m_2 = 80$ kg and $F = 1000$ N].



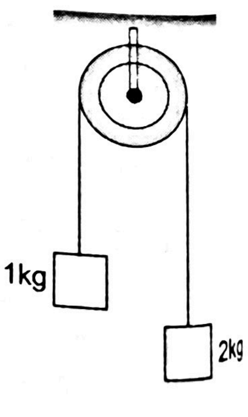
(i)



(ii)

(a) 7 : 2
(b) 2 : 7
(c) 3 : 4
(d) 4 : 3

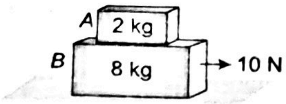
229. Two unequal masses are connected on two sides of a light string passing over a light and smooth pulley as shown in figure. The system is released from rest. The larger mass is stopped 1.0 second after the system is set into motion and then released immediately. The time elapsed before the string is tight again is: Take $g = 10$ m/s^2



(a) 1/4 s
(b) 1/2 s
(c) 2/3 s
(d) 1/3 s

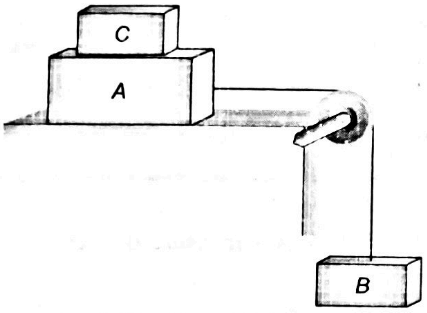
230. A hockey player is moving northward and suddenly turns westward with the same speed to avoid an opponent. The force that acts on the player is
(a) frictional force along westward.
(b) muscle force along southward.
(c) frictional force along south-west.
(d) muscle force along south-west.

231. Block A of mass 2 kg is placed over a block B of mass 8 kg. The combination is placed on a rough horizontal surface. If $g = 10\ \text{ms}^{-2}$, coefficient of friction between B and floor = 0.5, coefficient of friction between B and floor = 0.5, coefficient of friction between A and $B = 0.4$ and a horizontal force of 10 N is applied on 8 kg block, then the force of friction between A and B is



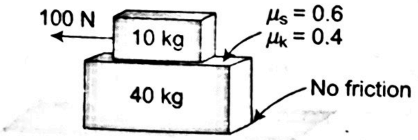
(a) 100 N
(b) 50 N
(c) 40 N
(d) None of these

232. Two masses A and B of 10 kg and 5 kg respectively, are connected with a string passing over a frictionless pulley fixed at the corner of a table as shown in fig. the coefficient of friction of A with the table is 0.2. the minimum mass of C that may be placed on A to prevent it from moving is



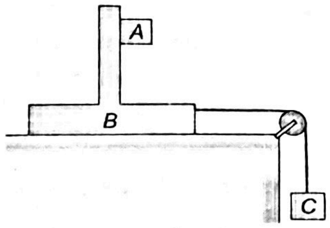
(a) 15 kg
(b) 5 kg
(c) 10 kg
(d) 0 kg

233. A 40 kg slab rests on a frictionless floor. A 10 kg block rests on top of the slab. The static coefficient of friction between the block and the slab is 0.60 while the kinetic coefficient of friction is 0.40. The 10 kg block is acted upon by a horizontal force of 100 N. The resulting acceleration of the slab will be



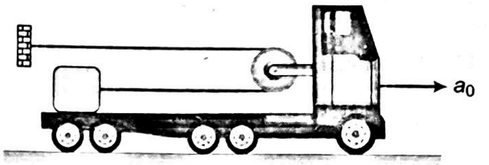
(a) $1.5\ \text{m s}^{-2}$
(b) $2.0\ \text{ms}^{-2}$
(c) $10\ \text{ms}^{-2}$
(d) $1.0\ \text{ms}^{-2}$

234. In the arrangement shown in the figure mass of the block B and A are 2 m, 8 m respectively. Surface between B and floor is smooth. The block B is connected to block C by means of a pulley. If the whole system is released then the minimum value of mass of the block C so that the block A remains stationary with respect to B is: (Coefficient of friction between A and B is μ and pulley is ideal)



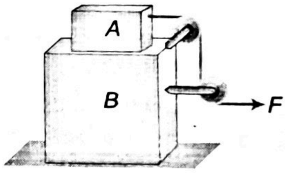
(a) $\dfrac{m}{\mu}$
(b) $\dfrac{2m}{\mu+1}$
(c) $\dfrac{10m}{1-\mu}$
(d) $\dfrac{10m}{\mu-1}$

235. A flat car is given an acceleration $a_0 = 2\ \text{m/s}^2$ starting from rest. A cable is connected to a crate of weight 50 kg as shown whose other end is attached to a fixed support on ground. Neglect friction between the floor and the car wheels and also the mass of the pulley. Calculate corresponding tension in the cable if $\mu = 0.30$ between the crate and the floor of the car.



(a) 350 N
(b) 250 N
(c) 300 N
(d) none of these

236. In the arrangement shown in figure, $m_A = m_B = 2$ kg. String is massless and pulley is frictionless. Block B is resting on a smooth horizontal surface, while friction coefficient between blocks A and B is $\mu = 0.5$. The maximum horizontal force F that can be applied so that block A does not slip over the block B is



(a) 25 N
(b) 40 N
(c) 30 N
(d) 20 N

237. The coefficient of friction between the block and the horizontal surface is μ. The block moves towards right under action of horizontal force F (figure-a). Sometime later another force P is applied to the block making an angle θ (such that $\tan\theta = \mu$) with vertical as shown in (figure-b). After application of force P, the acceleration of block shall

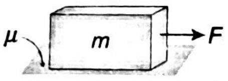


Figure-a

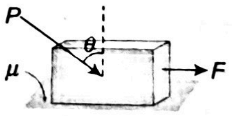
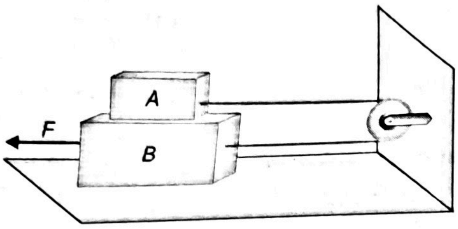


Figure-b

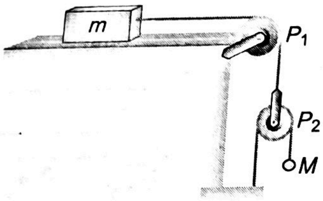
(a) increase
(b) decrease
(c) remains same
(d) information insufficient for drawing inference.

238. Two blocks A and B of masses $m = 10$ kg and $M = 20$ kg respectively are placed on each other and their combination rests on a fixed horizontal surface C. A light string passing over the smooth light pulley is used to contact A and B as shown. The coefficient of sliding friction between all surfaces in contact is $\mu = \frac{1}{4}$. If A is dragged with a force F then for both A and B to move with a uniform speed we have



(a) 175 N
(b) 100 N
(c) 125 N
(d) None of these

239. In the pulley arrangement shown, the pulley P_2 is movable. Assuming coefficient of friction between m and



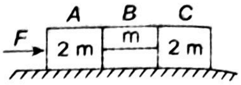
surface to be μ, the minimum value of M for which m is at rest is

(a) $M = \frac{\mu m}{2}$
(b) $m = \frac{\mu M}{2}$
(c) $M = \frac{m}{2\mu}$
(d) $m = \frac{M}{2\mu}$

240. A block placed on a horizontal surface is being pushed by a force F making an angle θ with the vertical. The coefficient of friction between block and surface is μ. The force required to slide the block with uniform velocity on the floor is:

(a) $\frac{\mu mg}{(\sin\theta - \mu\cos\theta)}$
(b) $\frac{(\sin\theta - \mu\cos\theta)}{\mu mg}$
(c) μmg
(d) none of these

241. The system is pushed by a force F as shown in figure. All surfaces are smooth except between B and C. Friction coefficient between B and C is μ. Minimum value of F to prevent block B from downward slipping is:



(a) $\left(\frac{3}{2\mu}\right)mg$
(b) $\left(\frac{5}{2\mu}\right)mg$
(c) $\left(\frac{5}{2}\right)\mu mg$
(d) $\left(\frac{3}{2}\right)\mu mg$

SECTION B: ASSERTION-REASONING QUESTIONS

In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as

(a) *If both assertion and reason are true and reason is the correct explanation of assertion.*
(b) *If both assertion and reason are true but reason is not the correct explanation of assertion.*
(c) *If assertion is true but reason is false.*
(d) *If both assertion and reason are false.*

1. **Assertion:** A rocket works on the principle of conservation of linear momentum.

   Reason: Whenever there is a change in momentum of one body, the same change occurs in the momentum of the second body of the same system but in the opposite direction.

2. **Assertion:** Pulling a lawn roller is easier than pushing it.

   Reason: Pushing increases the apparent weight and hence the force of friction.

3. **Assertion:** The familiar equation $mg = R$ for a body on a table is true only if the body is in equilibrium.

   Reason: The equality of mg and R has no connection with the third law.

4. **Assertion:** Mass is a measure of inertia of the body in linear motion.

   Reason: Greater the mass, greater is the force required to change its state of rest or of uniform motion.

5. **Assertion:** On a merry-go-around, all parts of our body are subjected to an inward force.

   Reason: We have a feeling of being pushed outward the direction of impending motion.

6. **Assertion:** A table cloth can be pulled from a table without dislodging the dishes.

   Reason: To every action there is an equal and opposite reaction.

7. **Assertion:** If external force on a body is zero, its acceleration is zero.

   Reason : This is the simple form of Newton's second law of motion.

8. **Assertion:** Newton's second law of motion gives the measurement of force.

   Reason: According to Newton's second law of motion, force is directly proportional to the rate of change of momentum.

SECTION A

1.	(d)	**2.**	(c)	**3.**	(c)	**4.**	(d)	**5.**	(a)	**6.**	(d)	**7.**	(d)	**8.**	(b)	**9.**	(d)	**10.**	(a)
11.	(b)	**12.**	(a)	**13.**	(b)	**14.**	(c)	**15.**	(c)	**16.**	(c)	**17.**	(b)	**18.**	(a)	**19.**	(a)	**20.**	(a)
21.	(a)	**22.**	(c)	**23.**	(a)	**24.**	(a)	**25.**	(b)	**26.**	(a)	**27.**	(d)	**28.**	(c)	**29.**	(c)	**30.**	(b)
31.	(d)	**32.**	(b)	**33.**	(b)	**34.**	(d)	**35.**	(a)	**36.**	(a)	**37.**	(d)	**38.**	(a)	**39.**	(b)	**40.**	(a)
41.	(c)	**42.**	(b)	**43.**	(c)	**44.**	(d)	**45.**	(c)	**46.**	(d)	**47.**	(a)	**48.**	(a)	**49.**	(a)	**50.**	(d)
51.	(a)	**52.**	(b)	**53.**	(c)	**54.**	(c)	**55.**	(a)	**56.**	(a)	**57.**	(a)	**58.**	(b)	**59.**	(c)	**60.**	(d)
61.	(c)	**62.**	(a)	**63.**	(a)	**64.**	(d)	**65.**	(d)	**66.**	(a)	**67.**	(d)	**68.**	(c)	**69.**	(c)	**70.**	(d)
71.	(a)	**72.**	(c)	**73.**	(b)	**74.**	(c)	**75.**	(d)	**76.**	(a)	**77.**	(d)	**78.**	(c)	**79.**	(d)	**80.**	(a)
81.	(c)	**82.**	(c)	**83.**	(d)	**84.**	(a)	**85.**	(c)	**86.**	(b)	**87.**	(a)	**88.**	(a)	**89.**	(d)	**90.**	(d)
91.	(b)	**92.**	(c)	**93.**	(b)	**94.**	(b)	**95.**	(a)	**96.**	(c)	**97.**	(b)	**98.**	(a)	**99.**	(b)	**100.**	(b)
101.	(a)	**102.**	(c)	**103.**	(c)	**104.**	(a)	**105.**	(a)	**106.**	(c)	**107.**	(a)	**108.**	(c)	**109.**	(c)	**110.**	(a)
111.	(b)	**112.**	(c)	**113.**	(b)	**114.**	(b)	**115.**	(b)	**116.**	(c)	**117.**	(a)	**118.**	(a)	**119.**	(a)	**120.**	(c)
121.	(b)	**122.**	(c)	**123.**	(a)	**124.**	(a)	**125.**	(d)	**126.**	(b)	**127.**	(c)	**128.**	(a)	**129.**	(c)	**130.**	(d)
131.	(c)	**132.**	(a)	**133.**	(d)	**134.**	(b)	**135.**	(d)	**136.**	(d)	**137.**	(b)	**138.**	(b)	**139.**	(a)	**140.**	(d)
141.	(a)	**142.**	(c)	**143.**	(a)	**144.**	(d)	**145.**	(d)	**146.**	(b)	**147.**	(a)	**148.**	(c)	**149.**	(d)	**150.**	(d)
151.	(a)	**152.**	(c)	**153.**	(a)	**154.**	(b)	**155.**	(d)	**156.**	(a)	**157.**	(c)	**158.**	(a)	**159.**	(a)	**160.**	(c)

161. (c) **162.** (a) **163.** (c) **164.** (c) **165.** (a) **166.** (c) **167.** (a) **168.** (b) **169.** (a) **170.** (b)
171. (a) **172.** (d) **173.** (d) **174.** (d) **175.** (a) **176.** (c) **177.** (c) **178.** (c) **179.** (c) **180.** (c)
181. (d) **182.** (b) **183.** (b) **184.** (b) **185.** (c) **186.** (c) **187.** (a) **188.** (c) **189.** (d) **190.** (d)
191. (a) **192.** (d) **193.** (d) **194.** (d) **195.** (a) **196.** (c) **197.** (a) **198.** (d) **199.** (c) **200.** (a)
201. (c) **202.** (d) **203.** (a) **204.** (a) **205.** (a) **206.** (b) **207.** (d) **208.** (c) **209.** (d) **210.** (b)
211. (a) **212.** (c) **213.** (b) **214.** (c) **215.** (b) **216.** (d) **217.** (c) **218.** (c) **219.** (b) **220.** (d)
221. (c) **222.** (d) **223.** (a) **224.** (b) **225.** (c) **226.** (d) **227.** (c) **228.** (c) **229.** (d) **230.** (c)
231. (d) **232.** (a) **233.** (d) **234.** (d) **235.** (a) **236.** (d) **237.** (c) **238.** (a) **239.** (a) **240.** (a)
241. (b)

SECTION B

1. (a) **2.** (a) **3.** (b) **4.** (a) **5.** (b) **6.** (b) **7.** (c) **8.** (a) **9.** (c) **10.** (c)
11. (a) **12.** (d) **13.** (b) **14.** (b) **15.** (a)